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ABSTRACT

This instructional unit consists of materials designed to help students understand terms associated with solar energy; identify components of advanced solar systems; and identify applications of solar energy in business, industry, agriculture, and photovoltaics. Included in the unit are the following materials: suggested activities, instructional materials (an objective sheet, an information sheet, and 38 transparency masters), and a list of references. A unit test and answer key are also provided. (MN)

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ED222673

A MODEL FOR INFUSING ENERGY CONCEPTS INTO VOCATIONAL EDUCATION PROGRAMS

ADVANCED SOLAR SYSTEMS

Project Number: E3176

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ADVANCED SOLAR SYSTEMS

UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with solar energy to their correct definitions or descriptions and identify components of advanced solar systems. The student should also be able to identify applications of solar in commercial, industrial, agriculture and photovoltaics. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with solar energy systems to their correct definitions or descriptions.
2. List six possible applications of solar process heat for commercial use.
3. Select characteristics of flat plate collectors in commercial and industrial applications.
4. Select characteristics of evacuated tube collectors for commercial and industrial application.
5. Select characteristics of parabolic trough concentrating collectors in commercial and industrial applications.
6. Select characteristics of parabolic dish collectors for industrial applications.
7. Select characteristics of heliostat/central receiver systems for industrial applications.
8. Match types of solar process heating systems of the past with their dates of operation.
9. List four values of solar industrial process heat systems.
10. List the approximate number of solar thermal manufacturers in 1980 with annual sales value.

11. Select companies that are using solar process heat.

12. List four industrial applications of solar process heat in the 1980's.

13. Select specific areas of concern for optimum design of solar process heat system applications.

14. List seven components of a solar powered irrigation system.

15. Select two types of solar grain drying systems.

16. List four types of solar collectors used with grain drying systems and list two advantages for each type.

17. Select three methods for transporting collected heat to the grain storage area.

18. List two concerns in sizing solar collectors for grain drying.

19. List two types of solar heating systems used in livestock buildings and give two common characteristics of active solar systems.

20. Match types of active air collectors for livestock buildings to their correct description of operation.

21. Discuss three types of active-system liquid-type solar collectors for livestock buildings.

22. Select three common materials used as heat storage for livestock buildings and two rule-of-thumb methods of sizing heat storage.

23. Select three statements on an in-building vertical wall collector and storage system.

24. Discuss the function of combination collector/rock storage and water type solar system with auxiliary boiler and water storage.

25. List nine applications of photovoltaic power systems.

ADVANCED SOLAR SYSTEMS

UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet
- B. Provide student with information sheet
- C. Make Transparencies
- D. Discuss unit and specific objectives
- E. Discuss information sheet
- F. Provide additional discussion and current state of the art materials and information on new advance solar projects and programs
- G. Give test

II. Student:

- A. Read objective sheet
- B. Study information Sheets
- C. Take test

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information Sheet
- C. Transparency masters
  1. TM 1--Flat Plate Collectors
  2. TM 2--Evacuated Tube Collectors
  3. TM 3--Parabolic Trough Concentrating Collectors
  4. TM 4--Parabolic Dish Concentrator Collectors
  5. TM 5--Heliostat System
  6. TM 6--Heliostat System (cont.)

7. TM 7--Solar Systems Of The Past
8. TM 8--Manufacturing Flat Plate Collectors
9. TM 9--Who's Using Solar Process Heat
10. TM 10--Who's Using Solar Process Heat (cont.)
11. TM 11--Solar Process Heat For The 80's
12. TM 12--Solar Process Heat For The 80's (cont.)
13. TM 13--Application Of Solar Process Heat Systems
14. TM 14--Solar Powered Irrigation Systems
15. TM 15--Trough Type Concentrating Collectors
16. TM 16--Rankine Freon Drive Engine
17. TM 17--Heat Transfer Fluid Pumps
18. TM 18--Solar Storage Tank
19. TM 19--Auxiliary Power System
20. TM 20--Plastic Collectors For Grain Drying
21. TM 21--Bare-Plate Collectors
22. TM 22--Covered Collector Plates
23. TM 23--Covered Collector Plates (cont.)
24. TM 24--Covered-Suspended-Plate Collector
25. TM 25--Transporting Collected Solar Heat
26. TM 26--Sizing Solar Collectors For Grain Drying
27. TM 27--The Passive System
28. TM 28a--Active System Air Collectors
29. TM 28b--Active System Liquid Solar Collector
30. TM 29--Values Of Common Storage Materials
31. TM 30--In-Building Storage System
32. TM 31--Separate Storage Systems

33. TM 32--Photovoltaic Power For Remote Applications

34. TM 33a--Solar Electric Appliances--Refrigerators

35. TM 33b--Solar Electric Appliances--Evaporative Cooler

36. TM 34--Solar Electric Pumping System

37. TM 35--AC and DC Photovoltaic Power System

38. TM 36--Solar Electric Fans

D. Test

E. Answers to test

II. Refererces

A. Planning for the Use of Solar Process Heat, Solar Energy Industries Association, Suite 800 1001 Connecticut Avenue, NW, Washington, DC 20036 (202) 293-2981

B. Homann Peter S.; Hilleary Chris J., Solar Heating Materials Handbook-Evironmental and Safety Considerations for Selection. Anachour, Inc., 2420 Alamo SE, Albuquerque, New Mexico, 1981

C. Alvis Robert L., Solar Powered Irrigation Program Status Report, Sandia Laboratories, Albuquerque, New Mexico, 87115

D. Friday William H.; Jones Don D., Solar Heating Systems for Confinement Livestock Buildings, Cooperative Extension Service, Purdue University, West Lafayette, Indiana 47907

E. Foster George H.; McKenzie Bruce A., Solar Heat For Grain Drying-Selection, Performance, Management, Cooperative Extension Service, Purdue University, West Lafayette, Indiana, 47907

ADVANCED SOLAR SYSTEMS

UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Corrosion--The wearing away of a material by physical and/or chemical processes

B. Elastomer--A rubber-like, often synthetic, polymer that has elastic properties

C. Inhibitor--An additive to fluids which slows the rate of chemical breakdown of fluids

D. Insulation--A material that retards the flow of heat

E. Outgassing--The emission of volatile additives, contaminants, or breakdown products

F. Passive system--A solar heating system that does not require an input of nonsolar energy to function

G. Selective coating--An absorber coating that has low longwave emittance and high solar absorptance

H. Thermal degradation--Decomposition of materials at high temperatures

I. Thermal expansion--Increases in length or volume when the temperature is increased

J. Thermal shock--Response of a material when it comes in contact with another material that has a much higher or lower temperature

K. Thermal storage medium--A material used to retain heat in storage until it is needed

L. Toxicity--The capability of a material to cause illness, death or damage to living tissue

M. UV (Ultraviolet)--A high energy radiation that makes up a portion of solar radiation

N. Viscosity--Resistance of a fluid to flow

O. Weathering--The degradation of a material when exposed to the elements of outdoor atmosphere

P. pH--The hydrogen ion concentration in a liquid

Q. Reflectance--The ratio of energy reflected by a surface to the energy incident on the surface

R. Curing--The process during which a sealant becomes a flexible solid with elastic properties

S. Emittance--A measure of the tendency of a surface to emit radiation

II. Commercial application of solar systems

A. Space heating

B. Absorption air conditioning

C. Hotwater for cleaning

D. Solar process heat for the use in;

1. Food processing
2. Temperature control of cleaning systems
3. Car washes
4. Laundries
5. Hotels
6. Motels
7. Schools
8. Clinics
9. Hospitals
10. Manufacturing processes
11. Steam generation
12. Power production

III. Characteristics of flat plate collectors in commercial and industrial applications--Transparency 1

A. Are the least expensive

B. Are the most widely used

C. Produce hot water to about 205°F

D. Are modular in design

E. Will provide heat energy on cloudy or partly cloudy days

F. Collector and receiver are the same

G. Are easy to install and maintain

IV. Characteristics of evacuated tube collectors for commercial and industrial application--Transparency 2

A. Are more efficient than flat plates

B. The receiver tube is enclosed in a glass tube with a vaccum or dead air between the two

C. Will provide heat energy in the 350°F range

D. Are easy to install and service

V. Characteristics of Parabolic trough concentrating collectors in commercial and industrial application--Transparency 3

A. Are line focusing collectors

B. Polished reflector surface directs the incident sunlight to the receiver tube

C. Will produce fluid temperatures up to 600°F

D. Are capable of producing fluids hot enough to operate steam or Rankine cycle engine generators for power production

E. Are capable of producing high temperatures for operation of Rankine cycle engine for direct drive of turbine shaft to equipment

VI. Characteristics of Parabolic dish collectors for industrial application--Transparency 4

A. Resemble a radar dish

B. Designed to focus sunlight at a focal point

C. Are designed for dual axes tracking

D. Theoretically can produce temperatures over 2000°F

E. Are capable of producing fluids at temperatures high enough for cogeneration

F. Are modular in design

G. Price reductions are expected in the early 1980's

VII. Characteristics of Heliostat/central receiver system for industrial applications--Transparency 5 and 6

A. Are also called power towers

B. The collector is remote to the receiver

C. Are designed for dual axes tracking

D. Are capable of producing temperatures in excess of 2000°F

E. Are designed to produce steam for power generation

F. May be adapted to industrial plant's existing boiler system for process heat

VIII. Solar process heat systems of the past--Transparency 7

A. Operation of printing press with dish type collector in 1882

B. Operation of plant machinery with concentrator collector system in 1883

C. Operation of solar irrigation pumping system with 50 HP capacity in 1912

D. Operation of process heat system with a parabolic dish collector in late 1890's

IX. Value of solar industrial process heat systems

A. Augment and integrate with conventional heat plants

B. Displace the consumption of fossil fuels when the sun shines

C. Saves fuel and fuel cost

D. Operation and maintenance of the solar energy plant requires similar basic skills as current fossil fuel plants

E. May be designed for preheat application using flat plate collector as well as concentrators

X. Availability of solar systems for commercial and industrial application

A. Approximately 350 solar thermal hardware manufacturers in 1980 with annual sales total of over 175 million

B. Installation of industrial process heat systems will run approximately 270,000 ft.^{2} of collectors per year as of 1980

C. Installation of medium temperature collectors are running over 3,000,000 square feet per year (1980)

D. Approximately 150 firms are involved in prototype development of solar process heat systems

E. Manufacturing flat plate collectors--Transparency 8

XI. Who's using solar process heat--Transparency 9 and 10

A. Disney World

B. Coca-Cola

C. Campbell's Soup

D. Lone Star Brewery

E. Johnson and Johnson

F. Anheuser-Busch Brewer

G. Sea World

H. Manufacturing Plants

XII. Solar process heat for industrial plants in the 80's

A. Will involve the use of many types of collectors to meet applications for;--Transparency 11 and 12

1. Heating and cooling

2. Power production

3. Process heat applications

4. Steam applications

XIII. Application of solar process heat systems--Transparency 13

A. Design will be site and application specific

B. Optimum design for each process will vary according to:

1. Temperature required

2. Flow rate of delivery system

3. Local climate

4. The availability of land or roof area

5. Type of heat exchange in place

6. The heat transfer medium to be used in the process

7. Cost of system installed

8. Return on investment

XIV. Solar powered irrigation system--Transparency 14

A. System components

1. Trough type concentrating collectors--Transparency 15

a. Automatic tracking

b. Capable of delivering 420°F heat transfer fluid to storage

2. Rankine freon drive engine--Transparency 16

a. Designed to deliver specific horsepower capacity to a drive shaft through use of a turbine

b. Uses refrigerant as the working fluid

c. Is operated by input of high temperature heat transfer fluid from the solar collector system

d. May be used to drive gear boxes, pumps or electric generators

3. Heat transfer fluid pumps--Transparency 17

   a. Special design pumps for high temperature use

   b. Pumps hot transfer fluid from storage to the freon drive engine

   c. Circulates transfer fluid from storage through the collector loop

4. Storage tank--Transparency 18

   a. Designed and insulated for storage of high temperature fluids

   b. Sized to provide operation of the solar system for a selected number of hours of night or cloudy conditions

5. Tracking system--Photoelectric control with electric motor to cogwheel drive

6. Auxiliary power system--Transparency 19

   a. Diesel driven generator sized to provide power for operation of system pumps, collector drive motors and installation lighting

   b. Power company supply connected for automatic changeover drive of irrigation pump

7. Irrigation pump motor

   a. Drive mechanism designed for operation by:

      1) Freon drive engine-direct coupling

      2) Electric power from power company

      3) Electric power from generator driven by solar powered freon drive engine

XV. Solar heat for grain drying

A. Types of solar grain drying systems

1. Combination high and low-temperature drying;

   a. High-speed, high-temperature pre-drying--Under this system, a high-speed, high temperature dryer is used first to bring the high-moisture grain down to a low moisture content

b. Slow-speed, low-temperature final drying--Grain is transferred from high temperature dryer for final drying using solar heated air

2. Low-temperature drying--A slow process that uses natural or slightly heated air that can be provided by solar

XVI. Types of solar collectors used for grain drying

A. Plastic collectors--Transparency 20

1. Advantages

a. Low cost

b. Easy on-site construction

c. May be formed or shaped as needed

2. Disadvantages

a. Requires a fan to inflate

b. Requires storage between seasons

c. Easily damaged

d. Must be protected from livestock, pets, etc.

B. Bare-plate collectors--Transparency 21

1. Noncovered channeled surfaces with air circulated underneath channels to pick up trapped heat

2. Advantages

a. Low cost

b. Simple to construct on metal buildings

3. Disadvantages

a. Relatively low in collection efficiency

b. Remains active during non-drying use

C. Covered-plate collectors--Transparency 22 and 23

1. Covered-plate collectors may be constructed as part of metal buildings or round grain bins

2. May be free-standing, built into the building or placed on top of existing roofs

3. The collector air passages may be manifolded and fans used to circulate air through the system at controlled flow rates to the dryer fan

4. Advantages

   a. Offers on site construction

   b. Relatively low cost

   c. Are more efficient than bare-plate collectors

5. Disadvantages

   a. Functions as collectors during non-drying times, thus maintaining high temperatures inside painted areas

D. Suspended-plate collectors--Transparency 24

1. Designed for air flow on both sides of the black absorber

2. Are generally free-standing with adjustable tilt

3. May be insulated to control heat loss

4. Is usually ducted into the dryer fan intake side

5. Advantages

   a. May be built as portable sections for storage during no use periods

   b. Relatively low cost

   c. Are very efficient

6. Have no apparent disadvantages

XVII. Transporting collected heat to the grain storage--Transparency 25

A. Use of air duct connected to the collector system and dryer fan

B. Use of outside air to control heat flow from collectors to dryer fan

c. Use of separate collector fan to deliver the recommended amount of solar heated air to the dryer fan intake

XVIII. Sizing solar collectors for grain drying--Transparency 26

A. Sized mainly as a source of supplement heat to surrounding air

B. Solar system should add approximately 20 - 40% of total heat required

(NOTE: A 5°F temperature rise by solar would represent a good percentage of total heat added to air.)

XIX. Solar heating systems for livestock buildings

A. Types of solar heating systems

1. The passive system--Transparency 27

a. Takes advantage of seasonal changes in the sun's angle to;

1) Collect solar energy through windows during winter months

2) Provides shading of windows during summer months

b. Managing temperature fluctuation in passive-heated space

1) Adding recommended insulation levels in walls and ceilings

2) Providing insulating glass in windows

3) Using insulating covers over windows at night

4) Use a ventilation system to control condensation

2. The active system

a. Common characteristics of active systems

1) A black-painted surface--to absorb the sun's rays, causing an increase in the temperature of that surface

2) A transfer medium--Usually air or water to pick up the heat absorbed and transfer it to storage or point of use

XX. Active system air type solar collectors for livestock buildings--Transparency 28

A. Covered-plate collector--air passes over one side only

B. Suspended-plate collector--air passes over both sides of the absorber

C. High-efficiency, suspended-plate collector--well insulated with double glazing

XXI. Active system liquid-type solar collectors--for livestock buildings--Transparency 28

A. Black tubes laid on the absorber surface

B. Tubes bounded to the absorber surface

C. Formed tube-in-sheet design with 360 degree contact between absorber surface and tube surface

XXII. Heat storage for livestock buildings

A. Common materials--Transparency 29

1. Rock

2. Concrete

3. Water

B. Size of storage--rule-of-thumb method

1. 1 1/2 cubic feet of solid concrete or rock for each square foot of collector surface

2. 4 gallons of water for each square foot of collector surface

XXIII. In-building vertical wall collector and storage system--Transparency 30

1. Double glazing over absorber blocks

2. Reflective cover for winter use

3. Collects, delivers, and stores solar heat

XXIV. Seperate storage systems for livestock buildings--Transparency 31

A. Combination--collector/rock storage

1. Air is circulated from collector through storage and back to collector

2. Air is circulated through air ducts buried in the rock storage to the livestock buildings and back

(Note: Recirculation of warm air from livestock building through rock or concrete to recover heat is not recommended because of dust and odor collection.)

B. Water type solar system with auxilary boiler and water storage

1. Solar heated water is circulated between the collectors and storage tank

2. Solar heated water is circulated through a liquid to air hydronic fan coil unit

3. Solar heated air is delivered to the livestock building space

4. The auxiliary boiler provides back up heat when storage water temperature is below the design temperature

XXV. Photovoltaic power systems

A. Applications for photovoltaic systems:

1. Residential electricity needs

2. Vacation cabins

3. Recreational vehicles

4. Remote power requirements--Transparency 32

5. Battery charging

6. Evaporative coolers--Transparency 33

7. Refrigeration--Transparency 33

a. For Storage of:

1) Medical supplies

2) Food

3) Ice

4) Other perishables

8. Solar electric pumping systems--Transparency 34

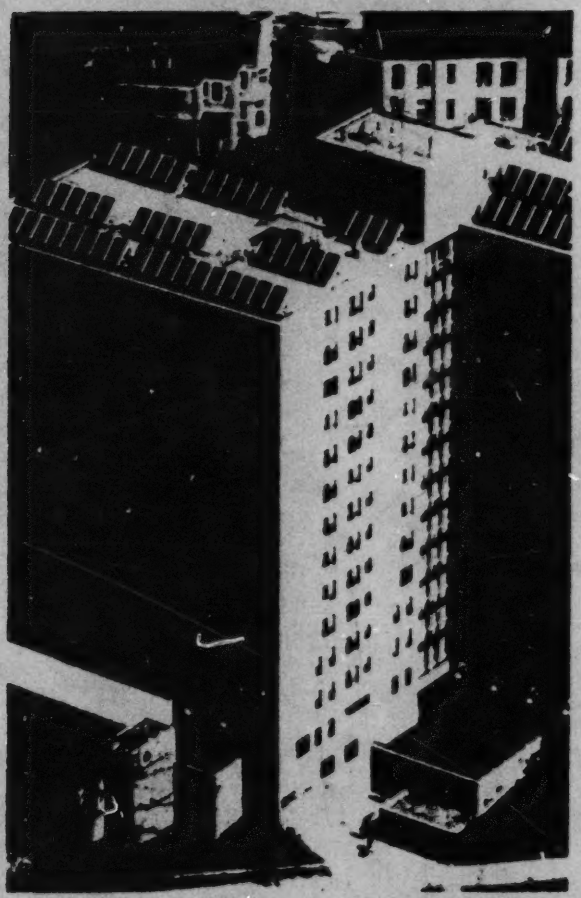
9. AC and DC photovoltaic power systems--Transparency 35

10. Solar electric fans--Transparency 36

a. Celing fan

b. Exhaust fan

FLAT PLATE COLLECTORS



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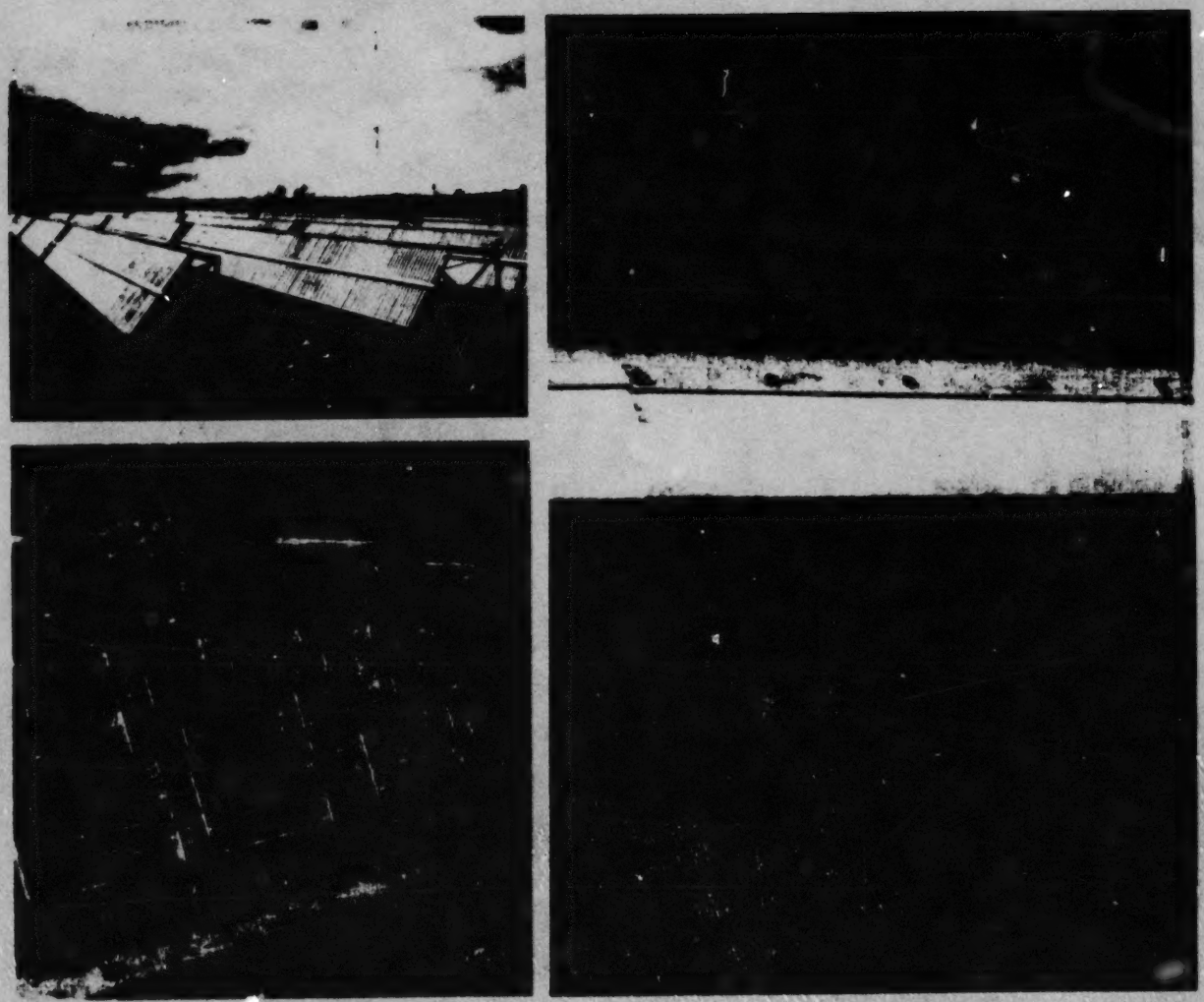
EVACUATED TUBE COLLECTORS



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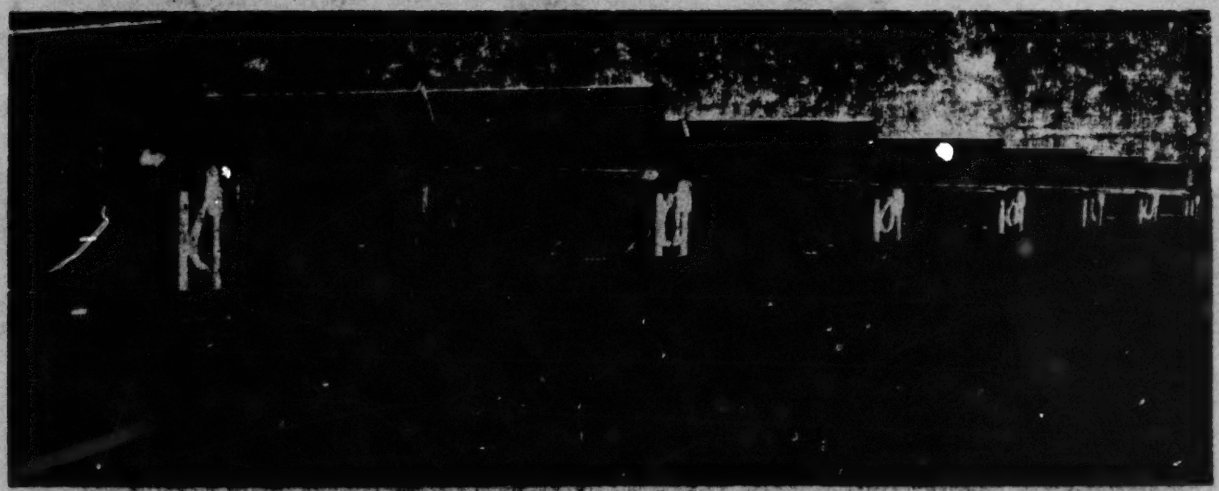
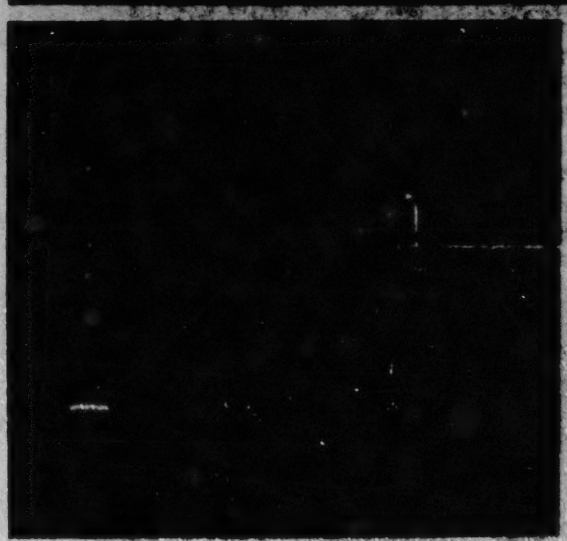
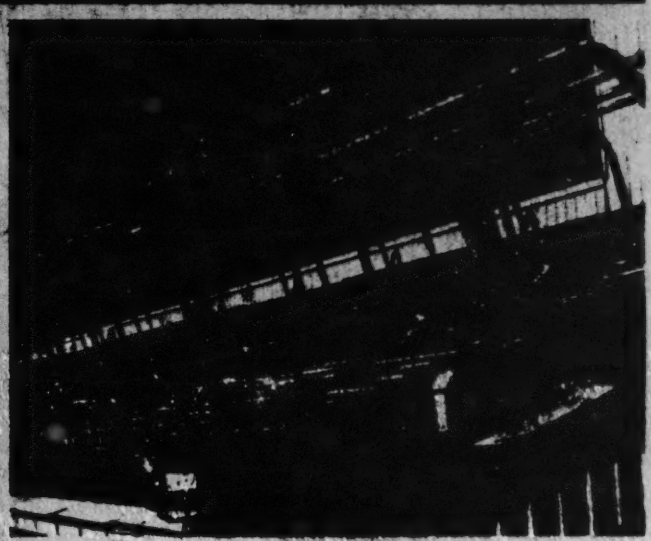
PARABOLIC TROUGH CONCENTRATING COLLECTOR







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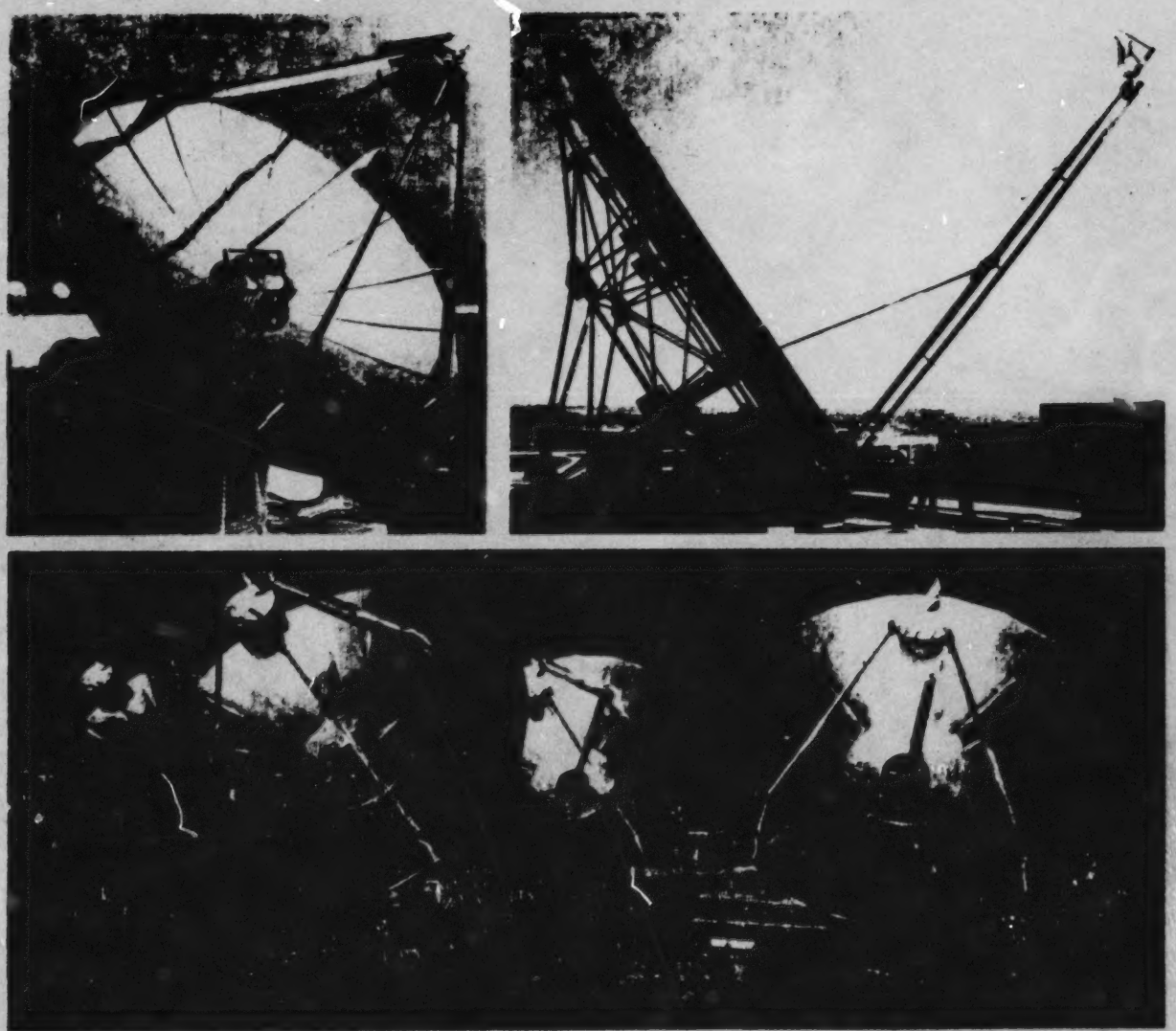
PARABOLIC DISH CONCENTRATOR COLLECTOR



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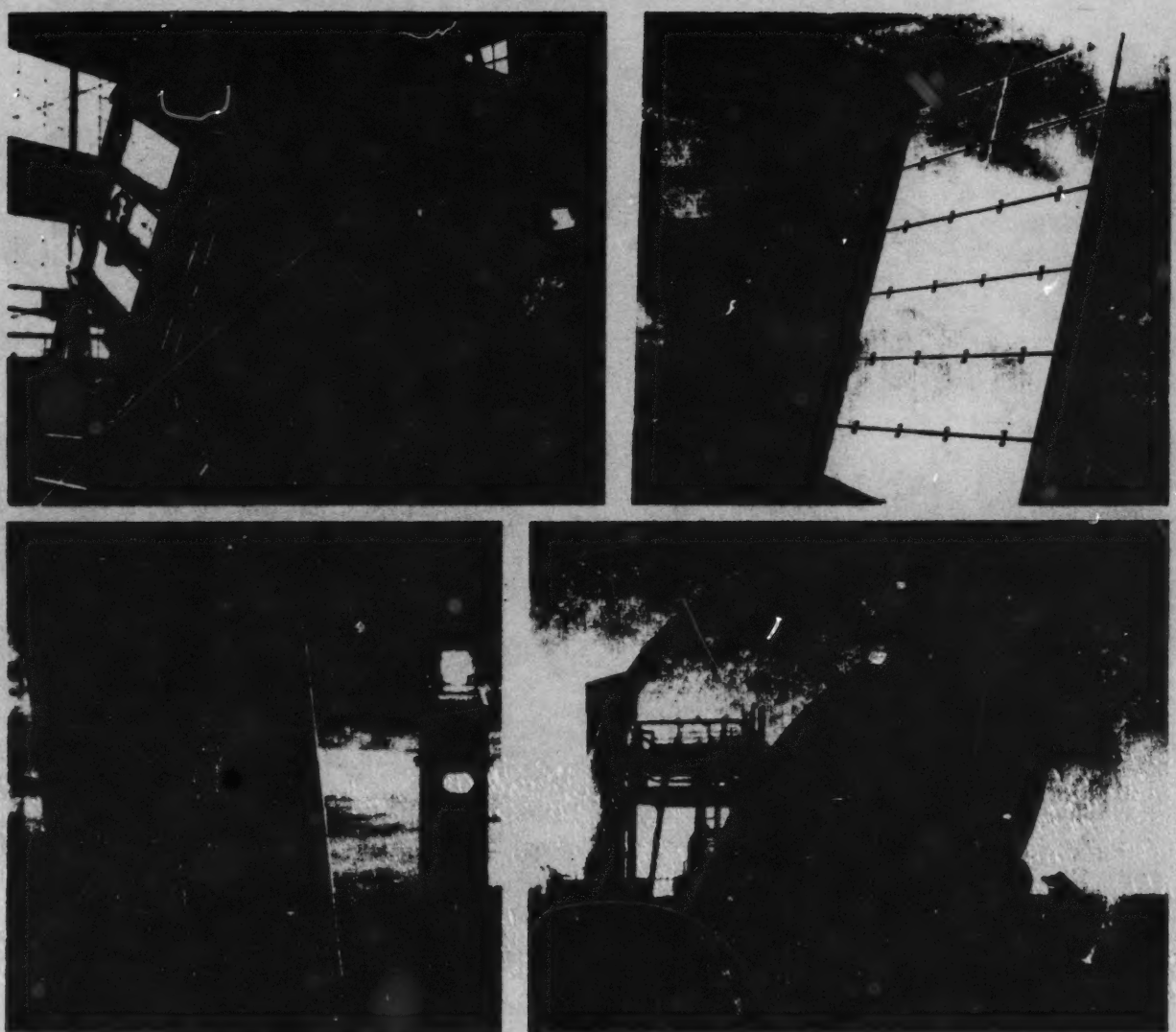
HELIOSTAT SYSTEMS



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HELIOSTAT SYSTEMS

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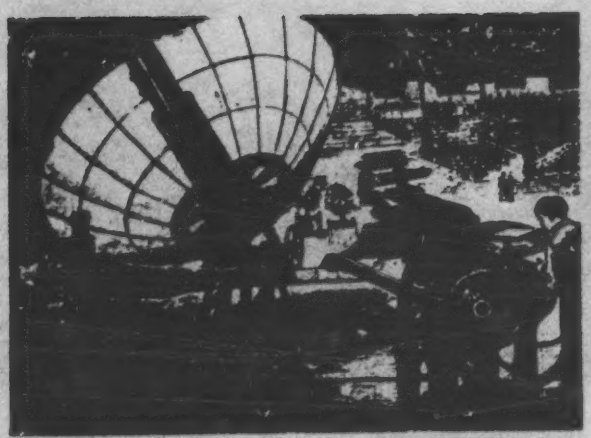
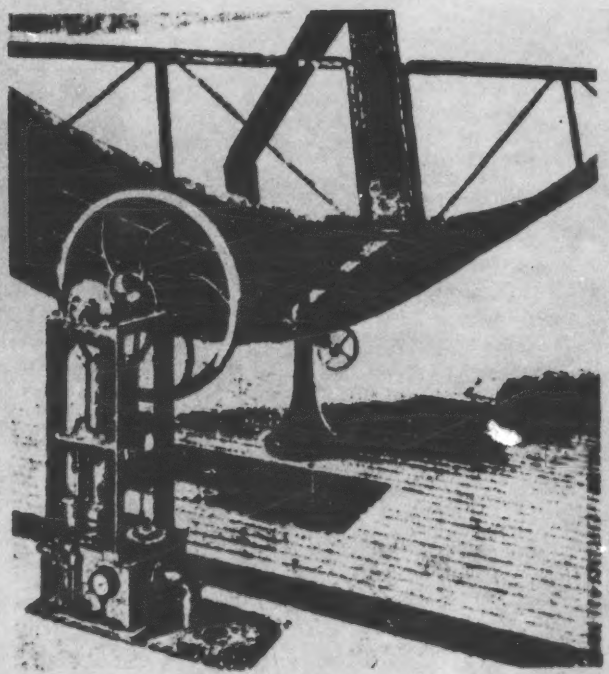
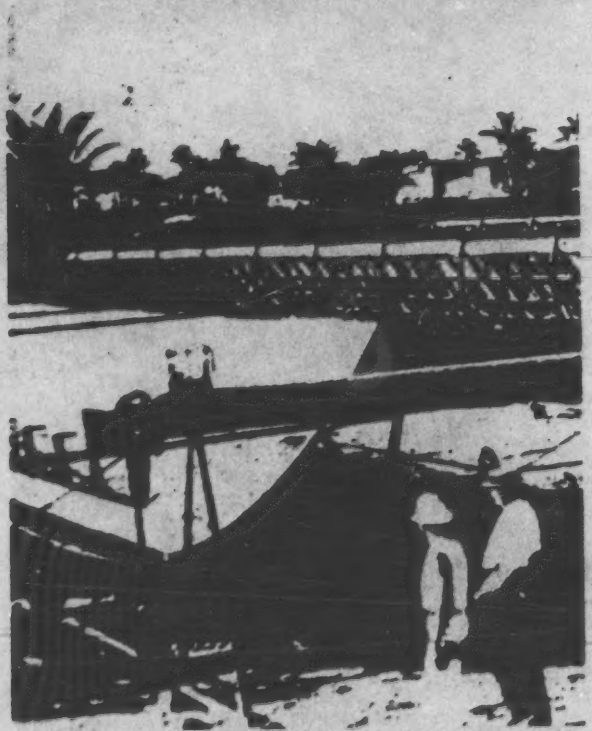
SOLAR SYSTEMS OF THE PAST



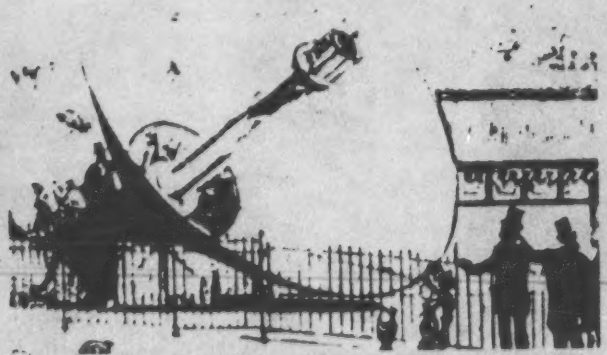
Printing press of "Le Journal Soliel" powered by solar collector (1882)



Ericsson's sun-power plant (1883)



50HP Solar thermal project in the Nile River Basin built by Shumin and boys in 1912.



Solar collector which was to be used at a turn of the century ostrich ranch in Pasadena.

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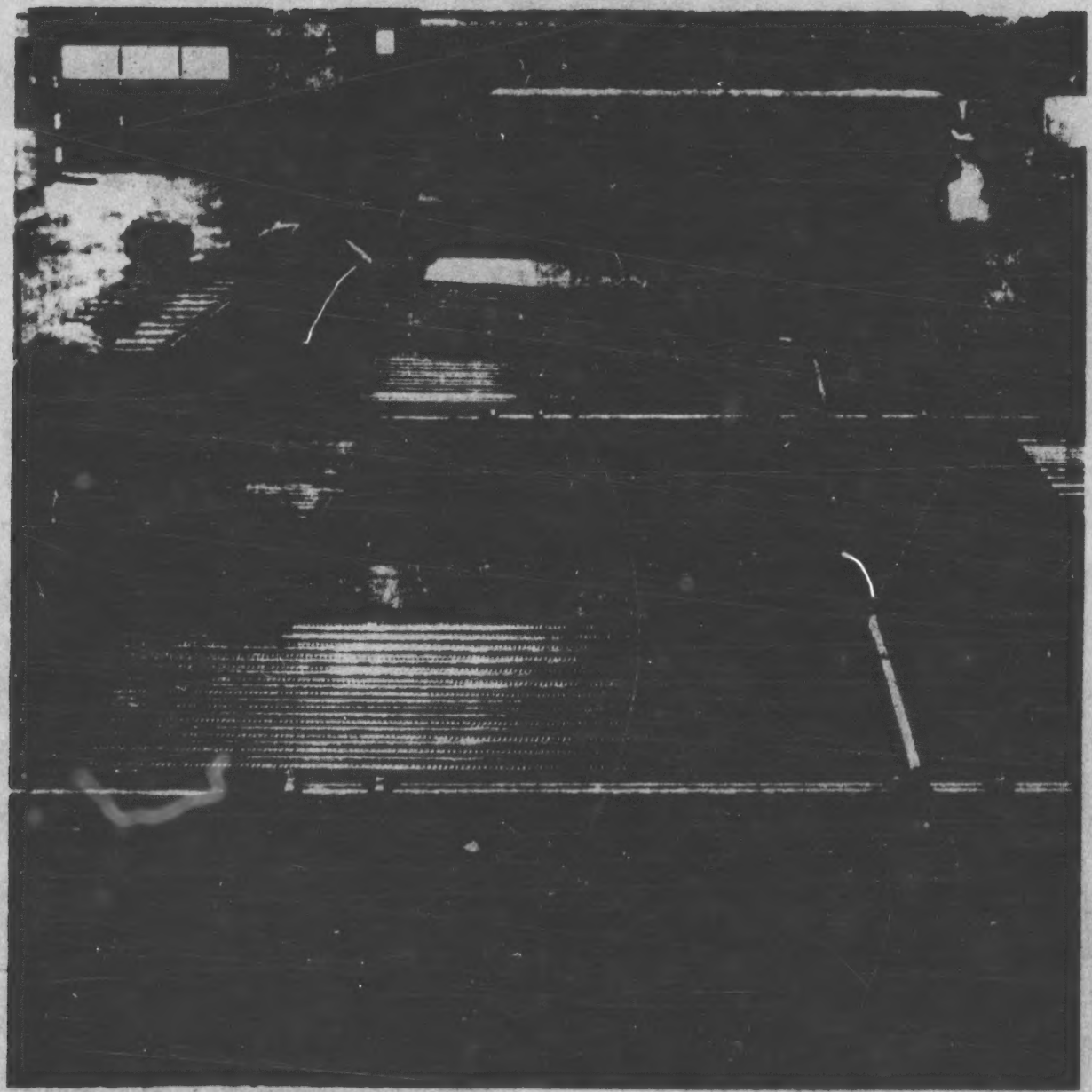
MANUFACTURING FLAT PLATE COLLECTORS



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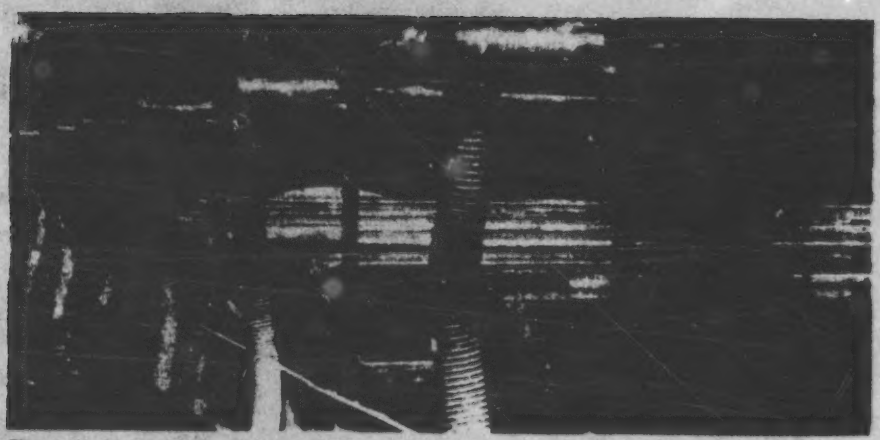
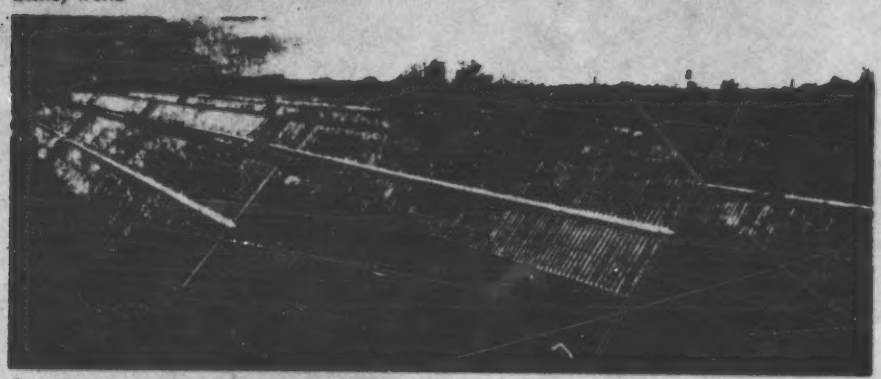
WHO'S USING SOLAR PROCESS HEAT?



Disney World



Coca-Cola

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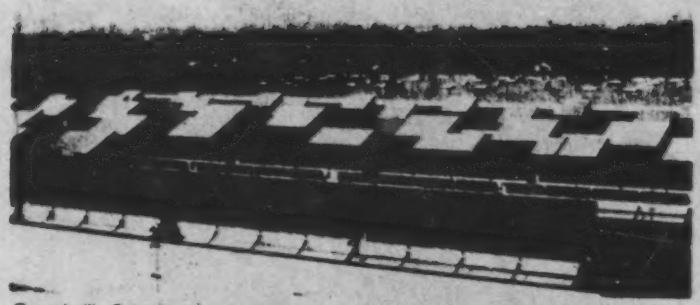
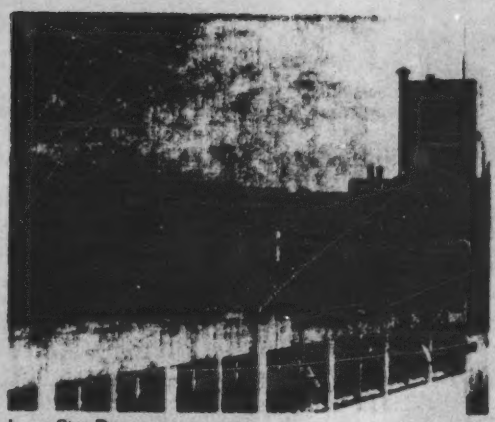
WHO'S USING SOLAR PROCESS HEAT

(CONT.)



Campbell's Soup



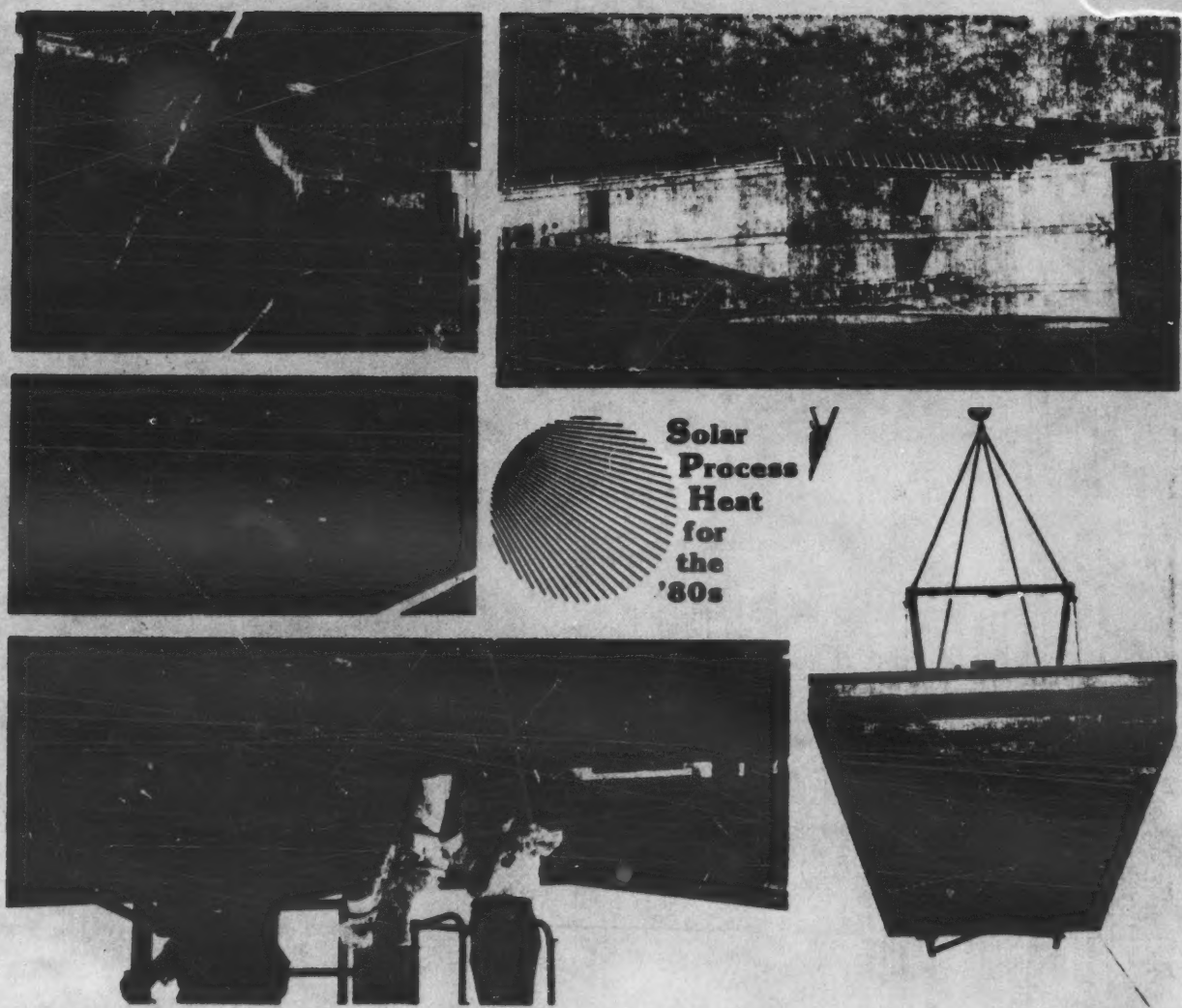
Lone Star Brewery

Johnson & Johnson

Anheuser-Busch Brewery

Courtesy of
SEIA

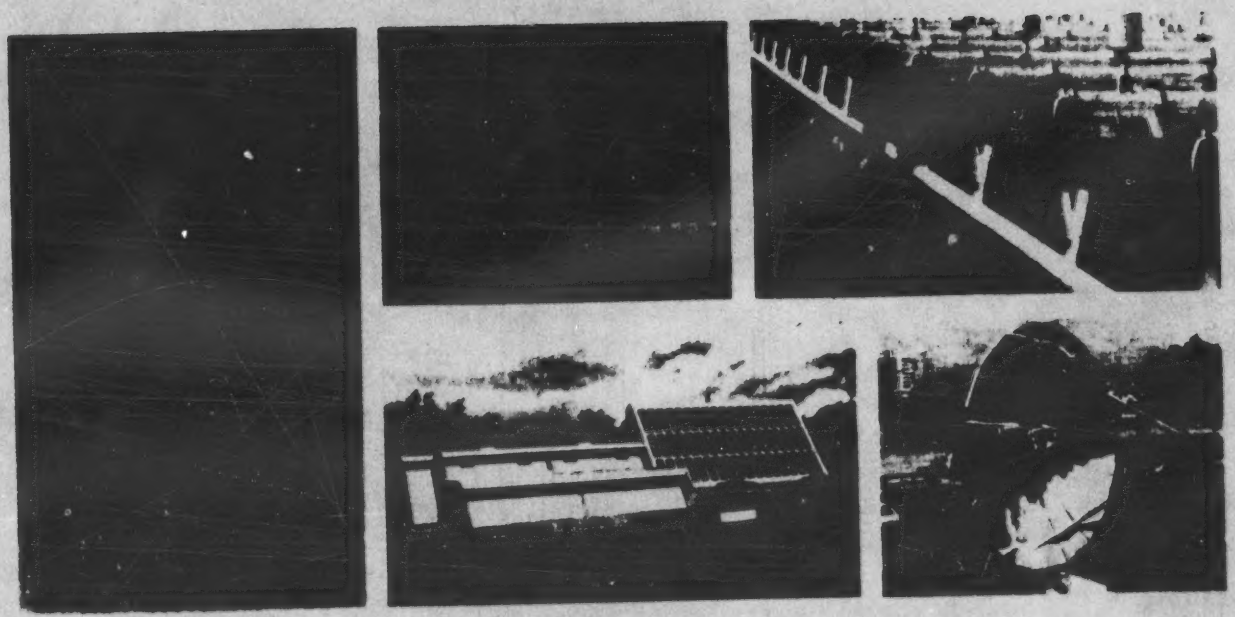
SOLAR PROCESS HEAT FOR THE '80s



Courtesy of
SEIA

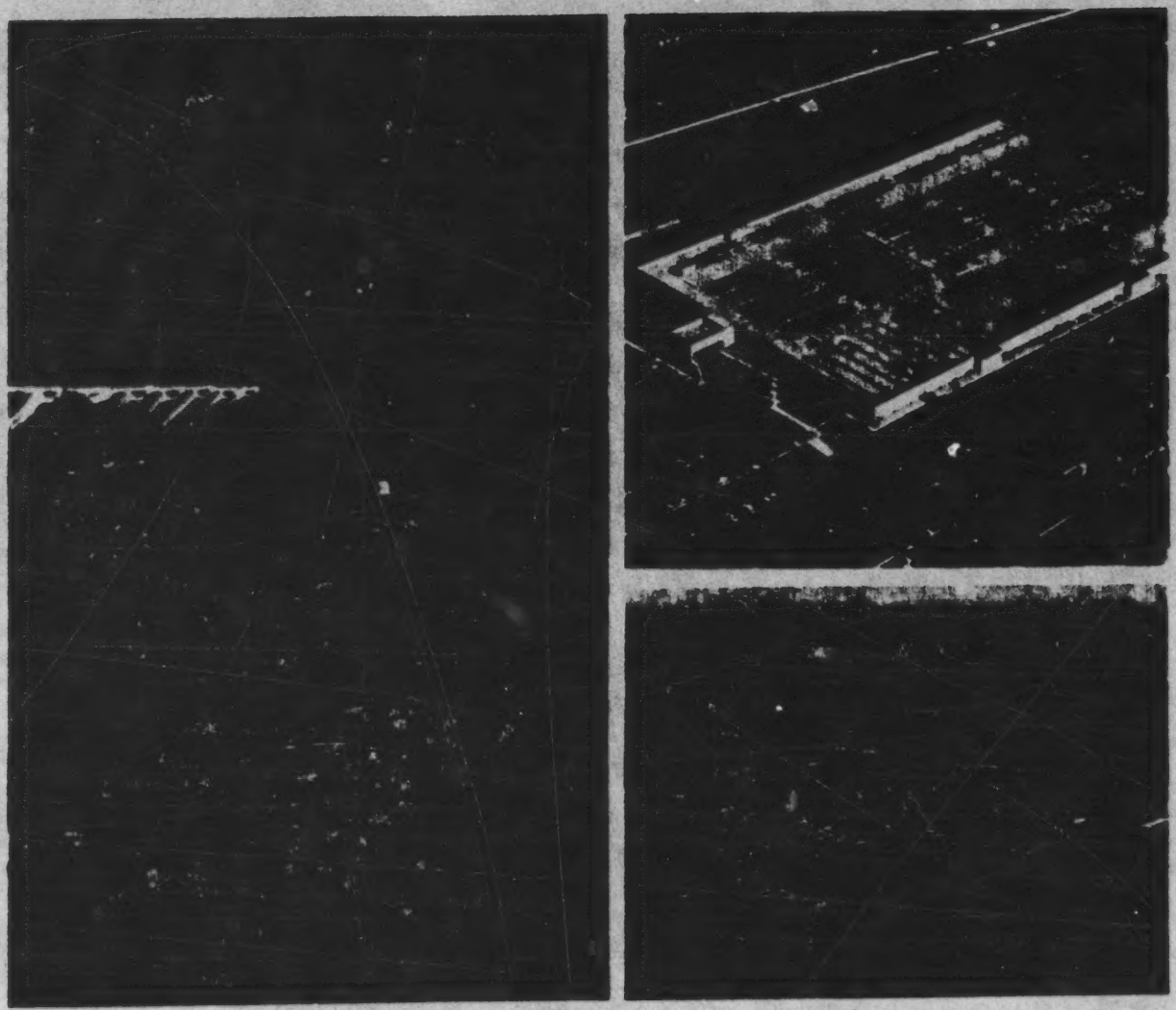
SOLAR PROCESS HEAT FOR THE '80s

(CONT.)



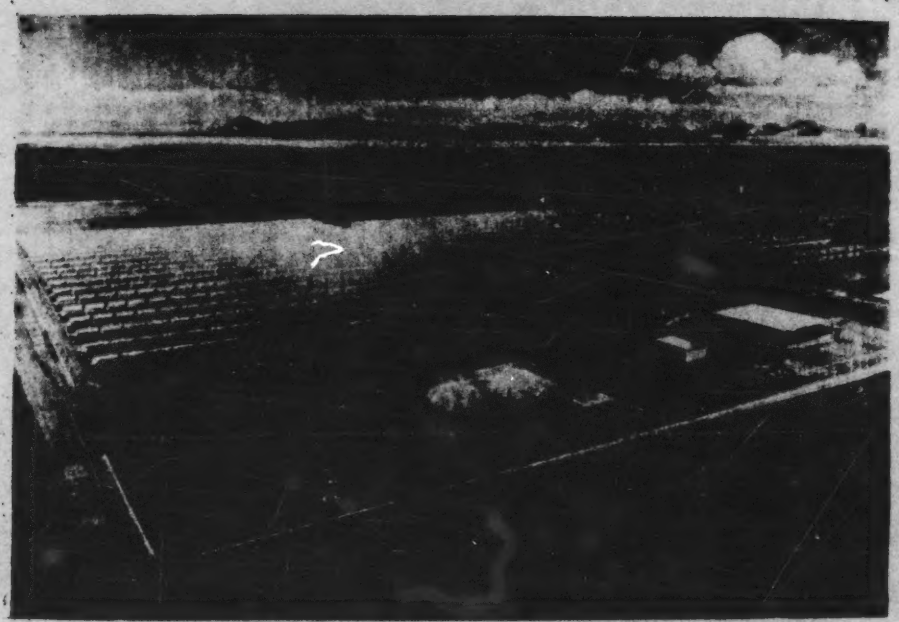
Courtesy of
SEIA

APPLICATION OF SOLAR PROCESS HEAT SYSTEMS

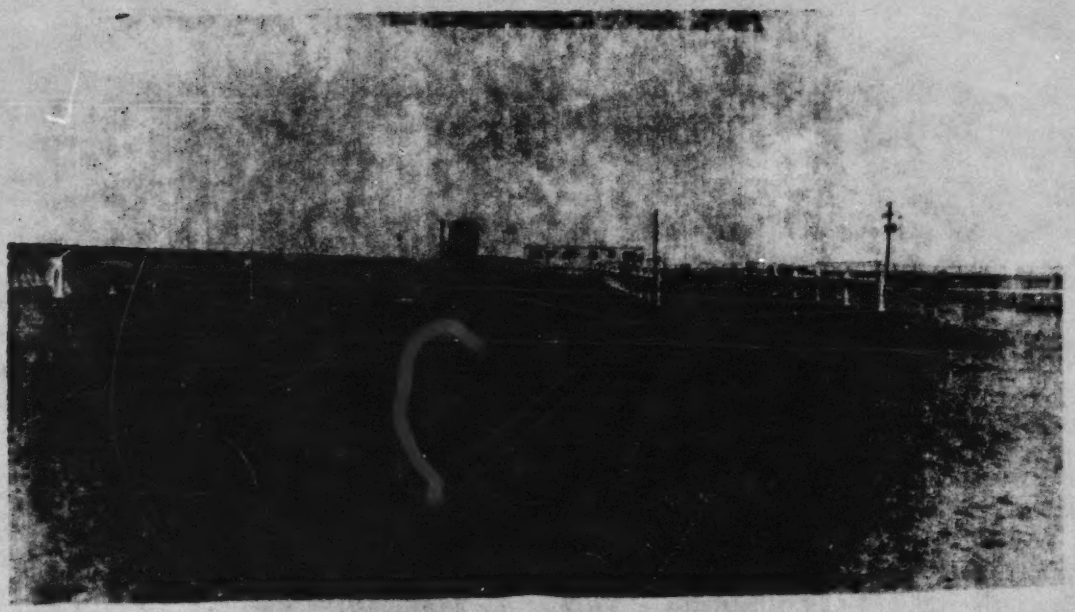


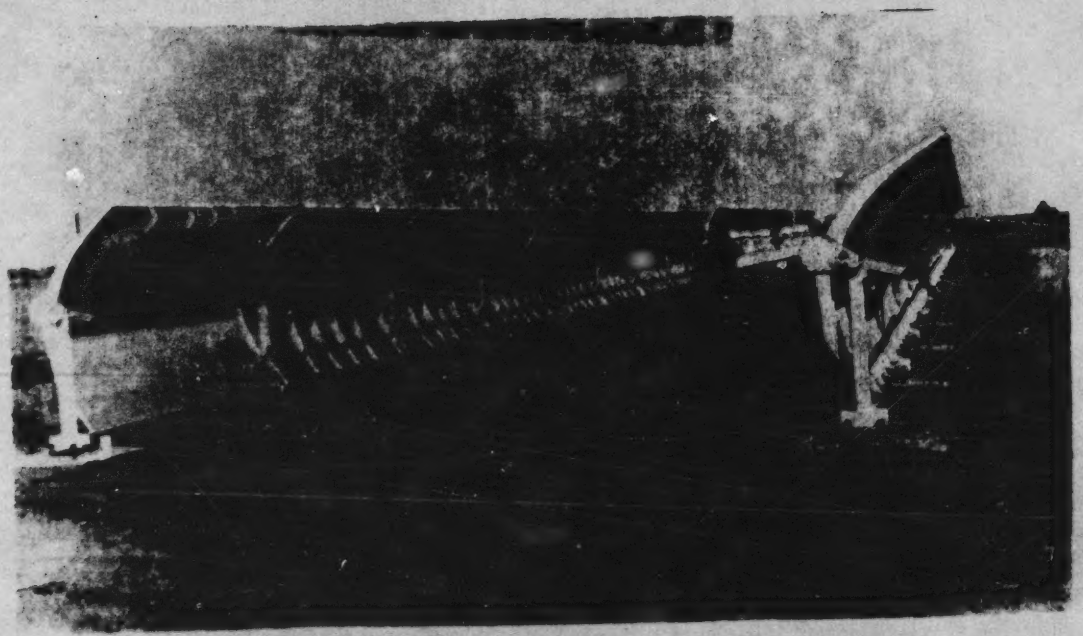
Courtesy of
SEIA

SOLAR POWERED IRRIGATION SYSTEM



TROUGH TYPE CONCENTRATING COLLECTORS





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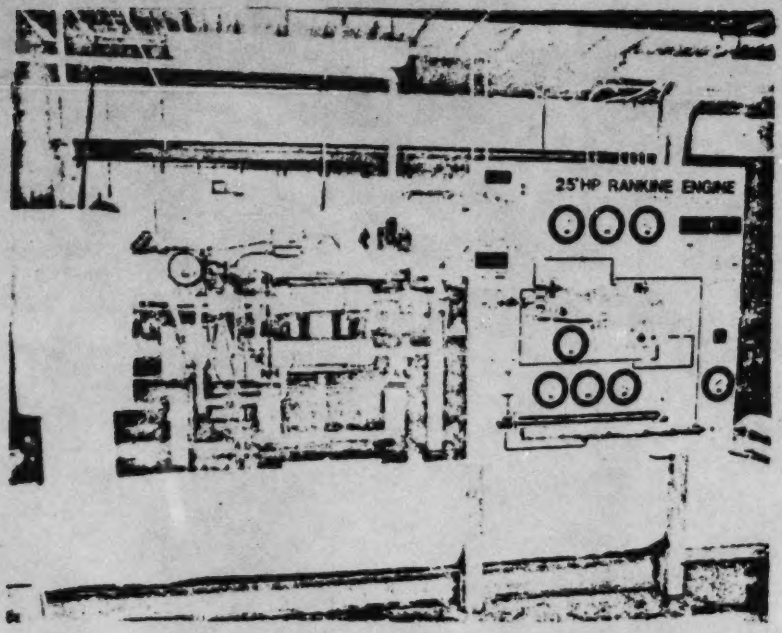
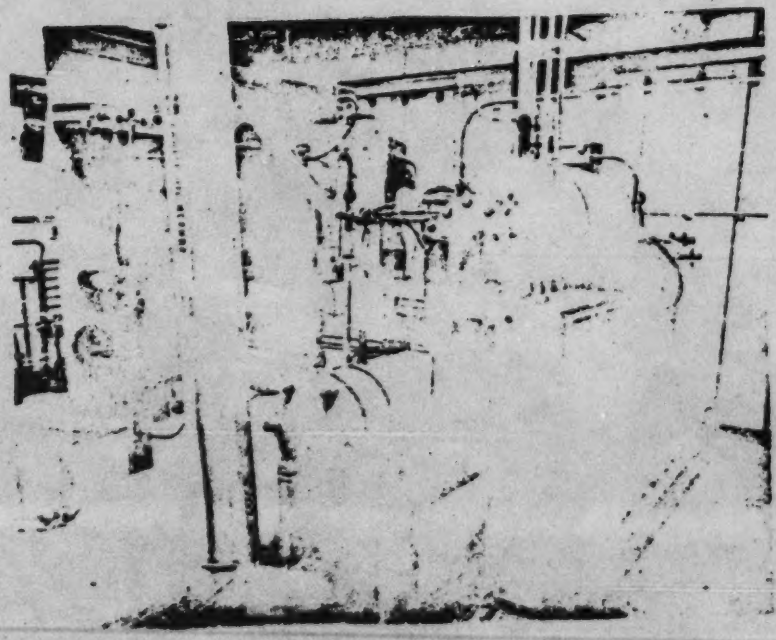
RANKINE FREON DRIVE ENGINE

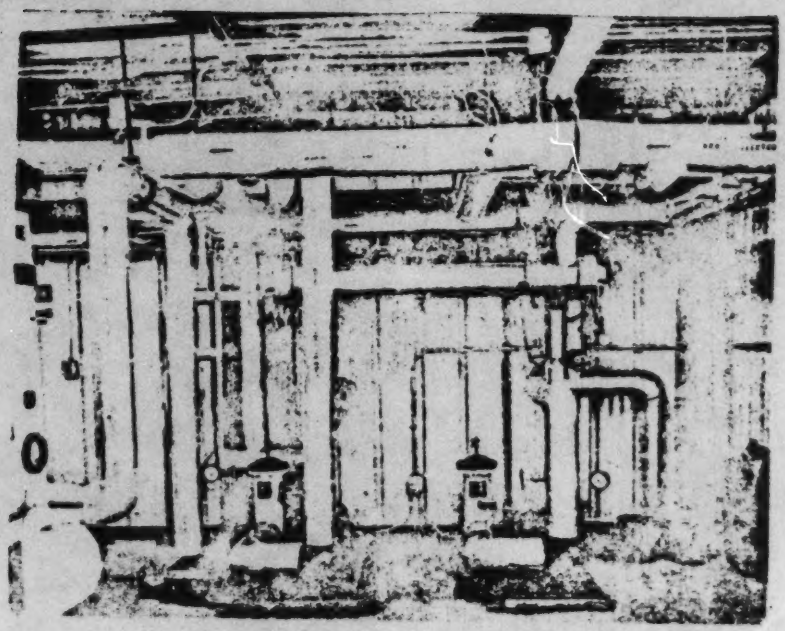


Left Side



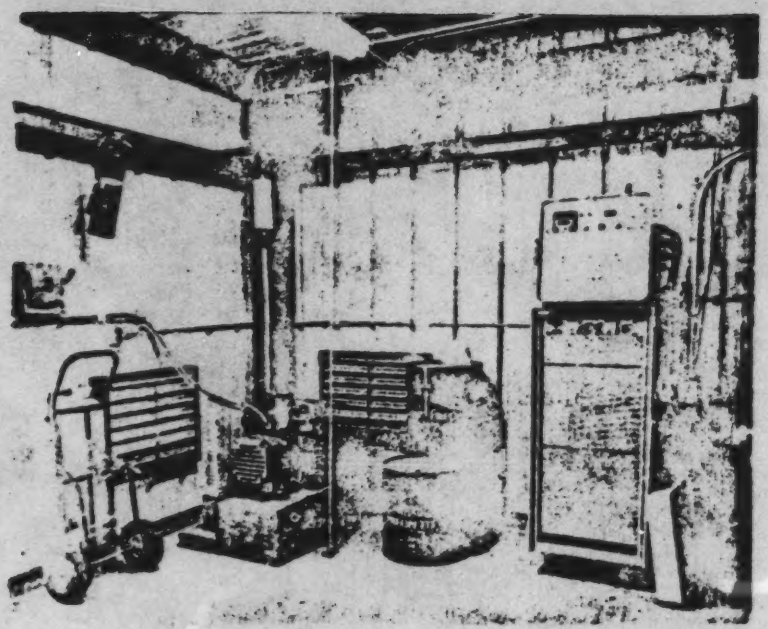
Right Side

HEAT TRANSFER FLUID PUMPS

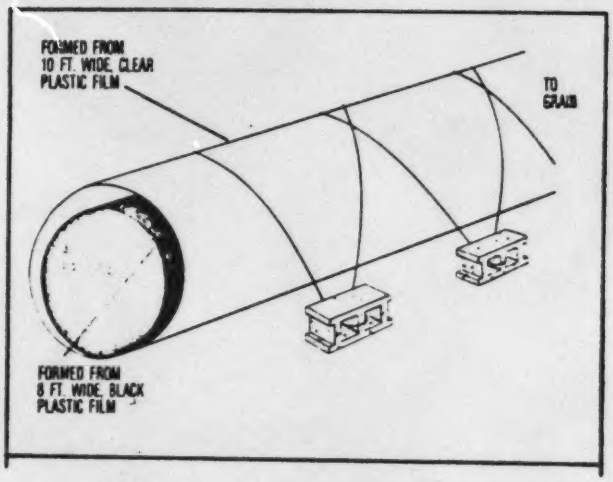


SOLAR STORAGE TANK

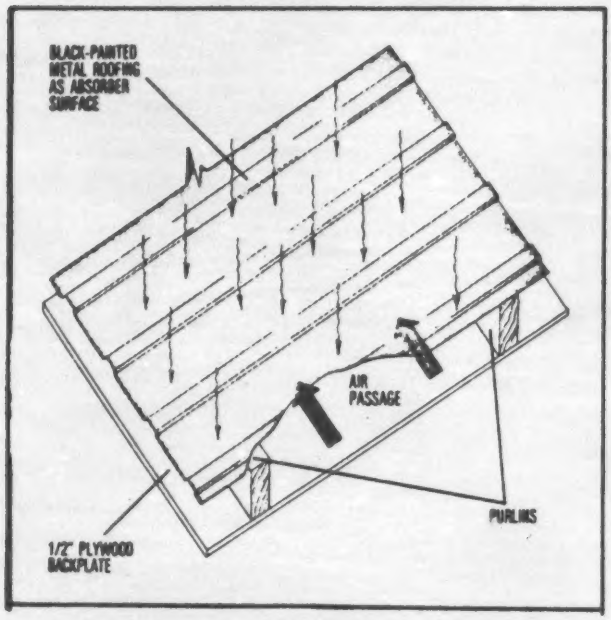
AUXILIARY POWER SYSTEM



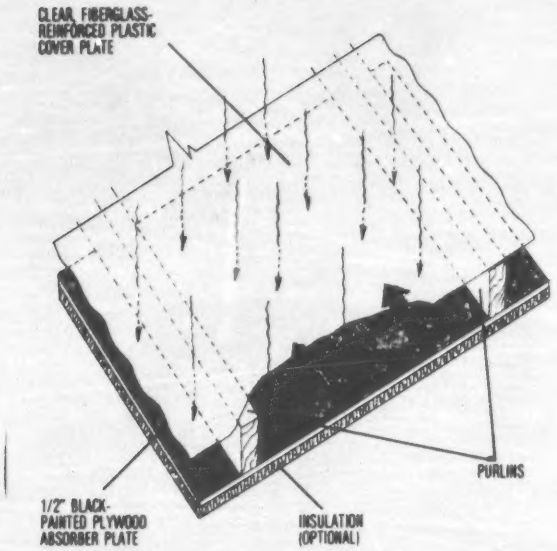
PLASTIC COLLECTORS FOR GRAIN DRYING

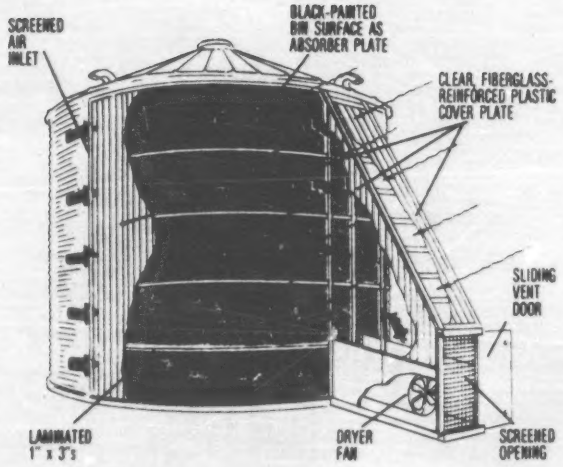


BARE-PLATE COLLECTOR



COVERED COLLECTOR PLATES





Using the grain bin wall as a covered-plate

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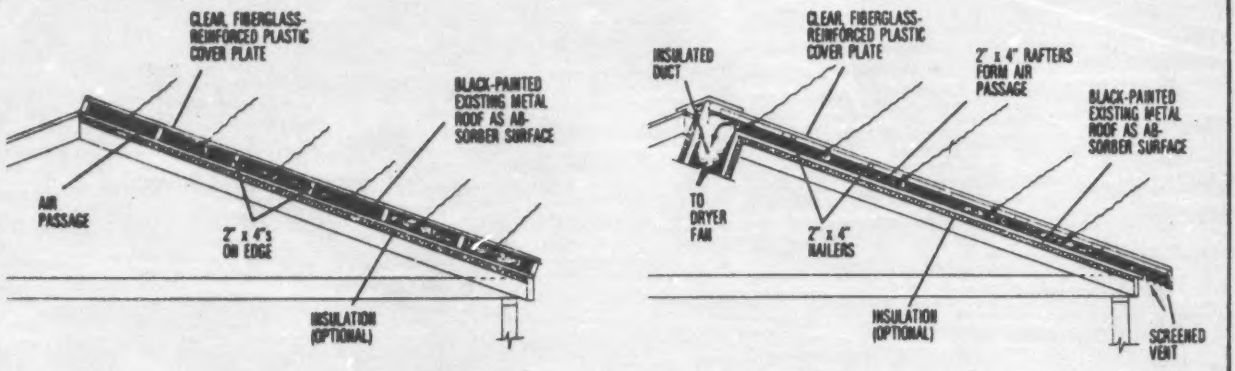
COVERED COLLECTOR PLATES

(CONT.)


CLEAR, FIBERGLASS-REINFORCED PLASTIC COVER PLATE
BLACK-PAINTED EXISTING METAL ROOF AS ABSORBER SURFACE
AIR PASSAGE
2" x 4"s ON EDGE
INSULATION (OPTIONAL)
INSULATED DUCT
CLEAR, FIBERGLASS-REINFORCED PLASTIC COVER PLATE
2" x 4" RAFTERS FORM AIR PASSAGE
BLACK-PAINTED EXISTING METAL ROOF AS ABSORBER SURFACE
TO DRYER FAN
2" x 4" NAILERS
INSULATION (OPTIONAL)
SCREENED VENT

Alternative methods of adding a covered-plate collector to an existing metal roof.

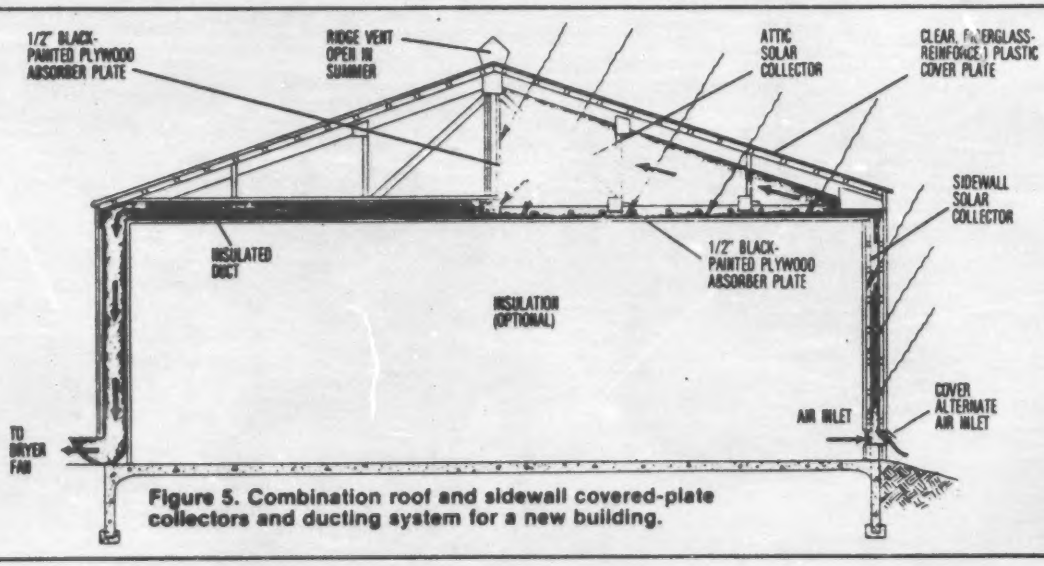
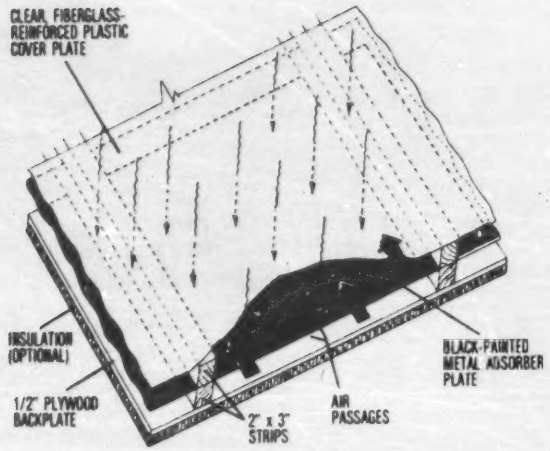
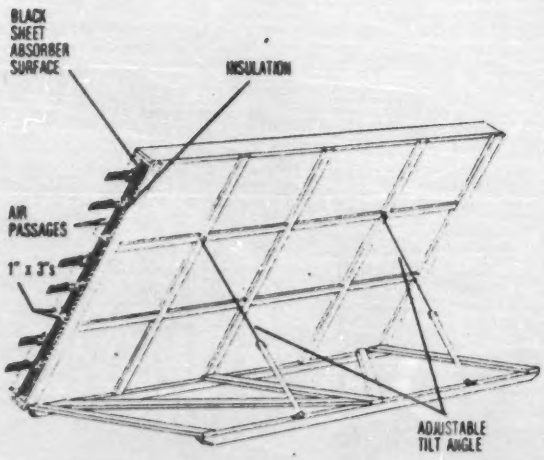


Figure 5. Combination roof and sidewall covered-plate collectors and ducting system for a new building.

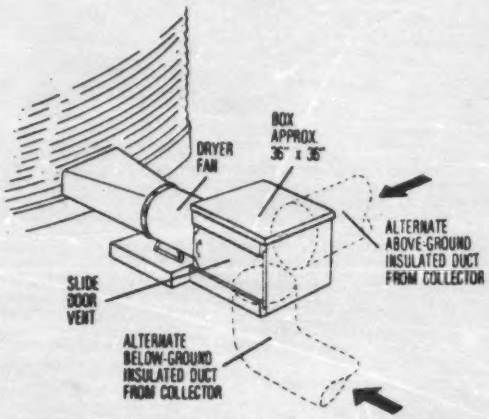
COVERED-SUSPENDED-PLATE COLLECTOR



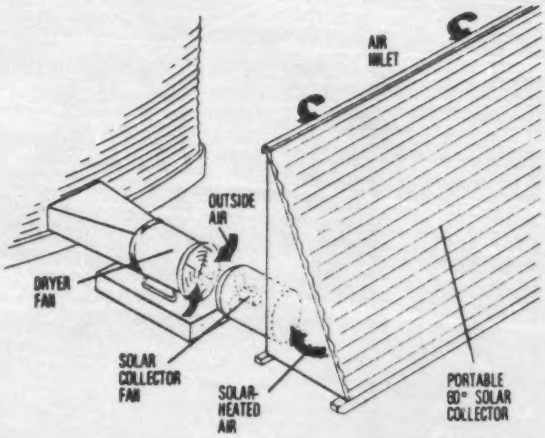


Free-standing, portable suspended-plate collector. (Side air inlet is screened.)

TRANSPORTING COLLECTED SOLAR HEAT


DRYER FAN
BOX APPROX. 36" x 36"
ALTERNATE ABOVE-GROUND INSULATED DUCT FROM COLLECTOR
SLIDE DOOR VENT
ALTERNATE BELOW-GROUND INSULATED DUCT FROM COLLECTOR

'Dog house' over the dryer fan to blend outdoor air with solar heated air.



A separate collector fan directs solar heated air to the drying fan.

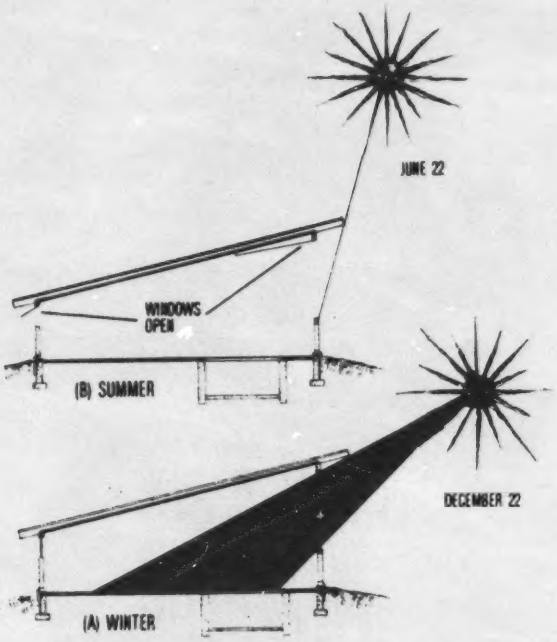
SIZING SOLAR COLLECTORS FOR GRAIN DRYING

Collector Area Required for Drying Grain by Selected Methods.[1]

Drying method (including needed air flow rate and desired temperature rise)	Maximum initial moisture	Collector type		
		Bare-plate	Covered-plate[2]	Suspended-plate
	percent	square feet per bushel		
Full-bin/low-temperature (2 cfm/bu. & 5° rise)	22	1/2-1	1/3-2/3	1/4-1/2
Full bin with stirring (2 cfm/bu. & 10° rise)	24	1-4	2/3-3	1/2-2
Layer drying with stirring[3] (10 cfm/bu. & 10° rise)	26	4-10	3-7	2-5
Batch-in-bin[4] (15 cfm/bu. & 15° rise)	28	20-30	15-20	10-15

[1] Based on average fall heat collection of 700 BTU/sq.ft. for suspended plate collector.
[2] Includes collectors built into or on building roofs and sidewalls
[3] Based on the number of bushels per layer.
[4] Based on drying a 1000-bushel batch in 24 hours.

THE PASSIVE SYSTEM



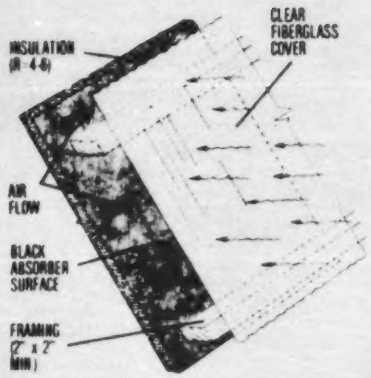
Livestock structures using passive solar radiation should be oriented east-west, facing south.

(A) In winter, plastic or glass windows on the south allow solar radiation to enter and be absorbed by the foundation, floor, walls, pen partitions and livestock. Energy is not re-radiated back out in large amounts, because the sun's rays lose energy after striking the animals and interior building surfaces; thus, temperature builds up.

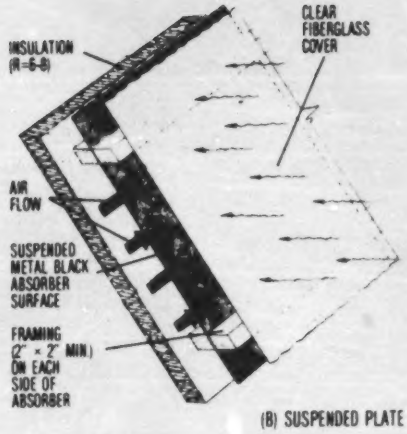
(B) In the summer, windows are shaded by a roof overhang or are covered to keep the building from overheating.

ACTIVE SYSTEMS COLLECTORS

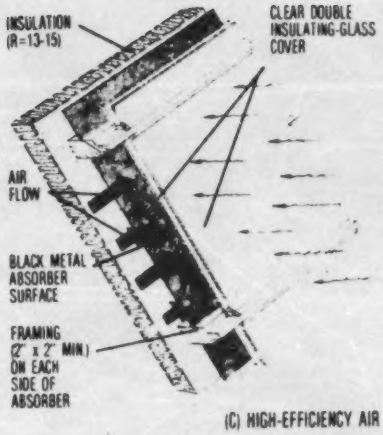
Hot Air



(A) COVERED-PLATE

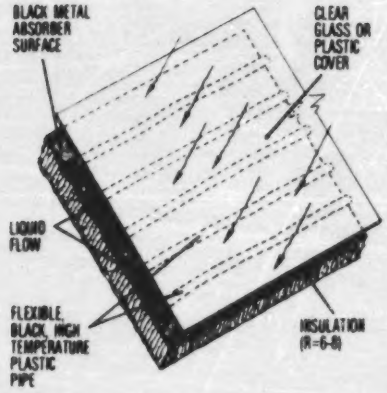

INSULATION (R=6-8)
CLEAR FIBERGLASS COVER
AIR FLOW
SUSPENDED METAL BLACK ABSORBER SURFACE
FRAMING (2" x 2" MIN.) ON EACH SIDE OF ABSORBER

(B) SUSPENDED PLATE

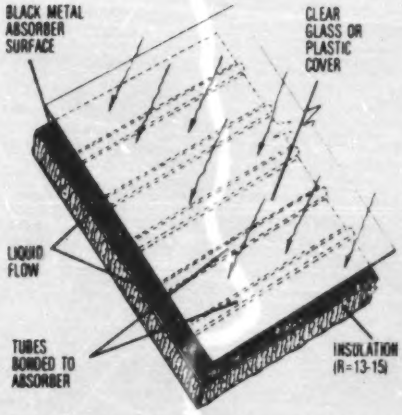

INSULATION (R=13-15)
CLEAR DOUBLE INSULATING-GLASS COVER
AIR FLOW
BLACK METAL ABSORBER SURFACE
FRAMING (2" x 2" MIN.) ON EACH SIDE OF ABSORBER

(C) HIGH-EFFICIENCY AIR

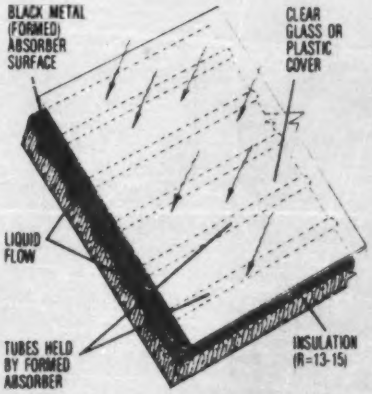
Liquid



(A) TUBES LAID IN BOX



(B) TUBES BONDED TO ABSORBER



(C) FORMED TUBE-IN-SHEET

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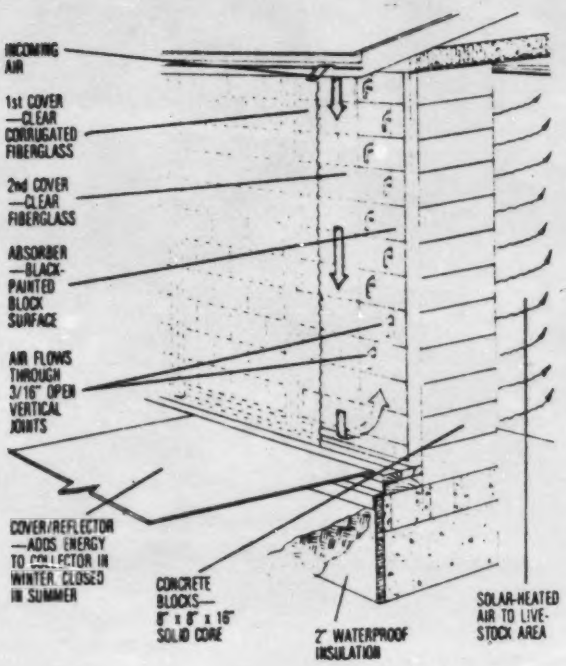
VALUES OF COMMON HEAT STORAGE MATERIALS

Heat Storage Values of Various Materials (for 50°F Temperature Rise).*

Storage material	BTU/ lbs.-°F	Lbs./ cu.ft.	BTU/ lbs.	BTU/ cu.ft.	BTU/ gal.
Water	1.0	62.4	50	3,120	417
Rock	.2	100	10.5	1,050	-
Concrete	.2	150	10.0	1,500	-
Salts	.5	56	108	12,500	-

* For a temperature rise less than 50°F, simply use a percentage of the table value. For example, a 30°F temperature rise in a water storage would provide a heat storage value of (30°F ÷ 50°F) x 417 BTU/gal. = 250 BTU/gal.

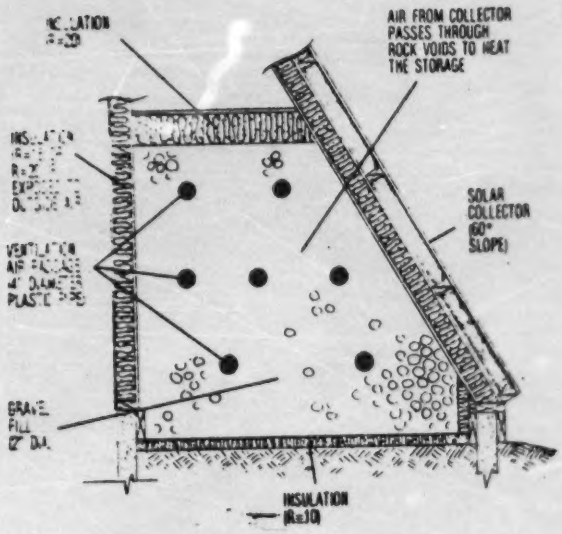
IN-BUILDING STORAGE SYSTEM


INCOMING AIR
1st COVER —CLEAR CORRUGATED FIBERGLASS
2nd COVER —CLEAR FIBERGLASS
ABSORBER —BLACK-PAINTED BLOCK SURFACE
AIR FLOWS THROUGH 3/16" OPEN VERTICAL JOINTS
COVER/REFLECTOR —ADDS ENERGY TO COLLECTOR IN WINTER, CLOSED IN SUMMER
CONCRETE BLOCKS— 8" x 8" x 16" SOLID CORE
2" WATERPROOF INSULATION
SOLAR-HEATED AIR TO LIVE-STOCK AREA

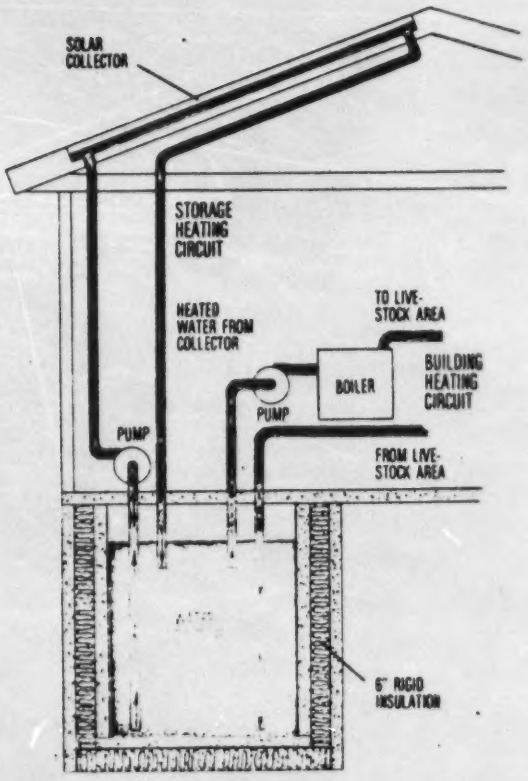
Design and operation of vertical sidewall collector/storage.

Ventilation air comes in under the eave, passes down between two fiberglass transparent cover plates. then up between the inner cover plate and concrete block wall, and through 3/16" vertical cracks left between the blocks, picking up solar heat absorbed by the blocks. Excess heat is stored in the concrete for use at night or on coludy days.

SEPERATE STORAGE SYSTEMS



Rock Storage



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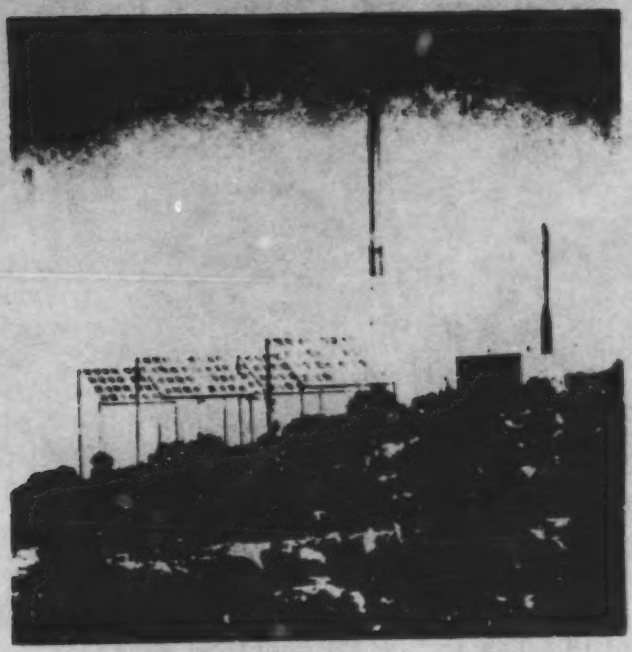
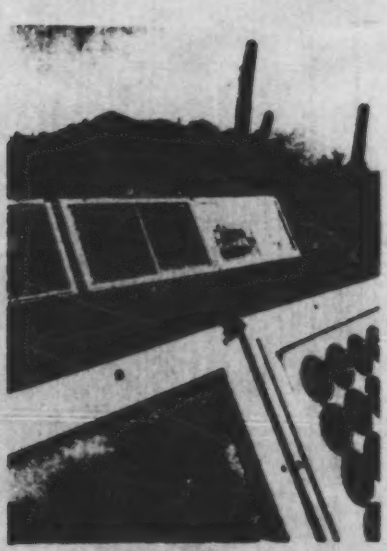
Water Storage

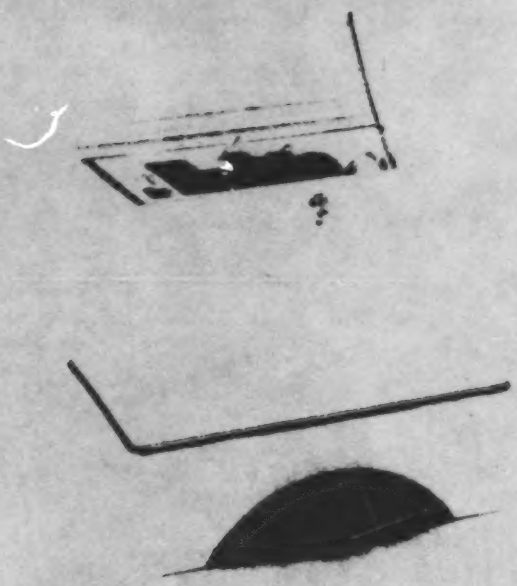
PHOTOVOLTAIC POWER FOR REMOTE APPLICATIONS



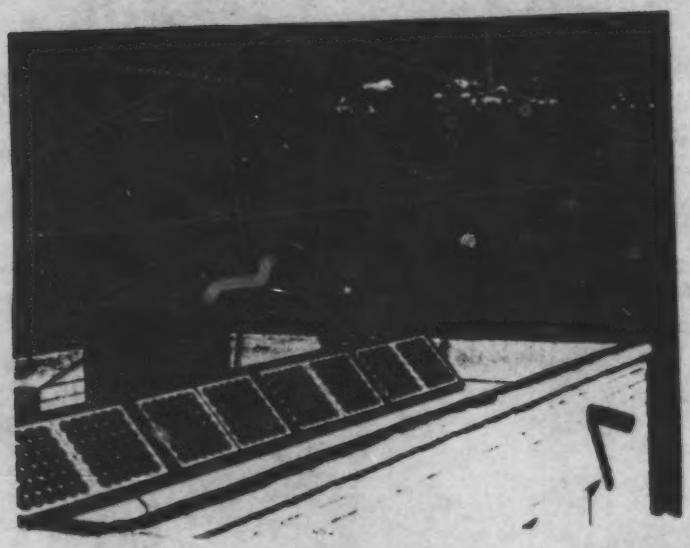


Courtesy of
MONEGON, LTD.

SOLAR ELECTRIC APPLIANCES



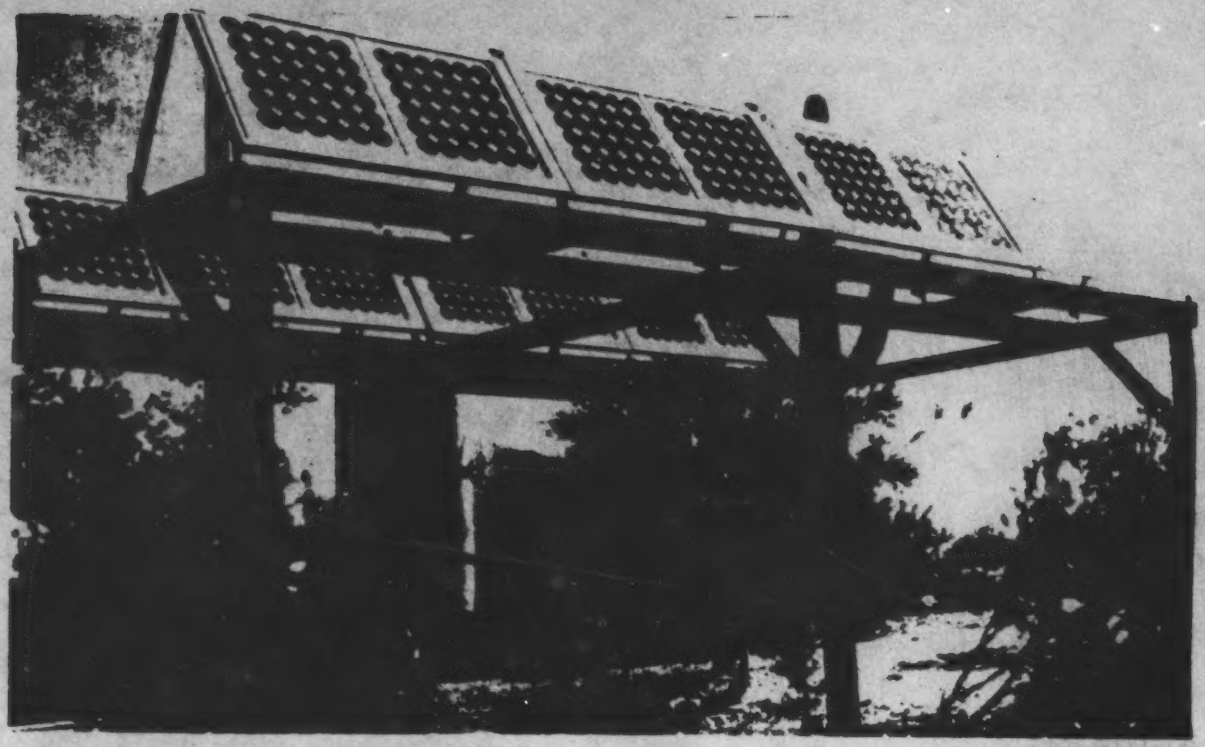
Solar Refrigerator

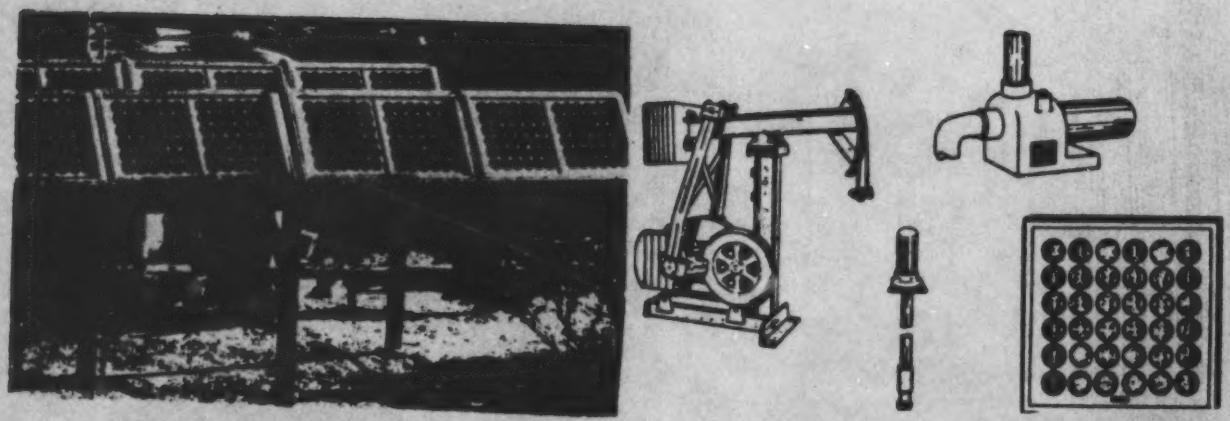


Solar Evaporative Cooler

Courtesy of
MONEGON, LTD.

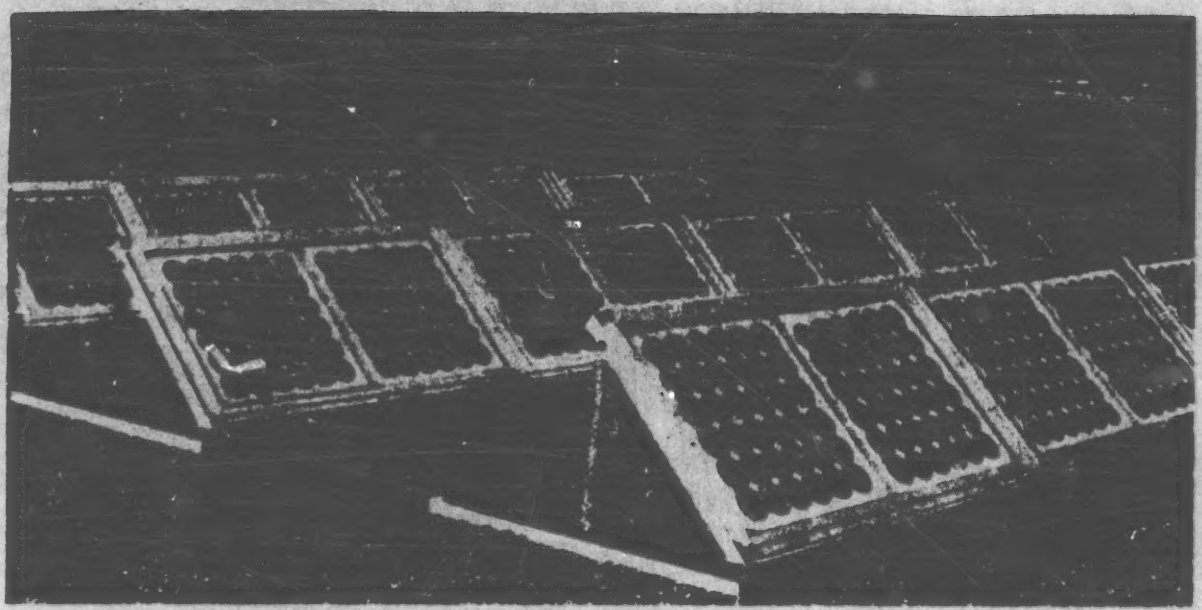
SOLAR ELECTRIC PUMPING SYSTEMS





Courtesy of
MONEGON, LTD.

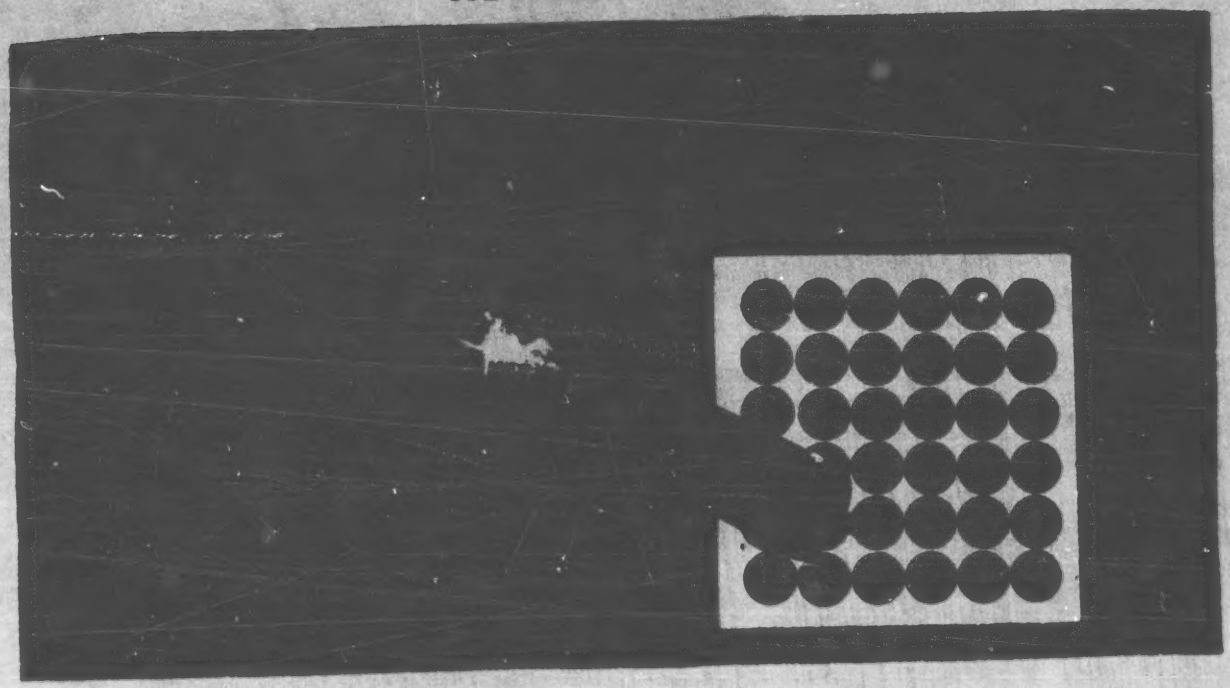
AC AND DC PHOTOVOLTAIC POWER SYSTEMS



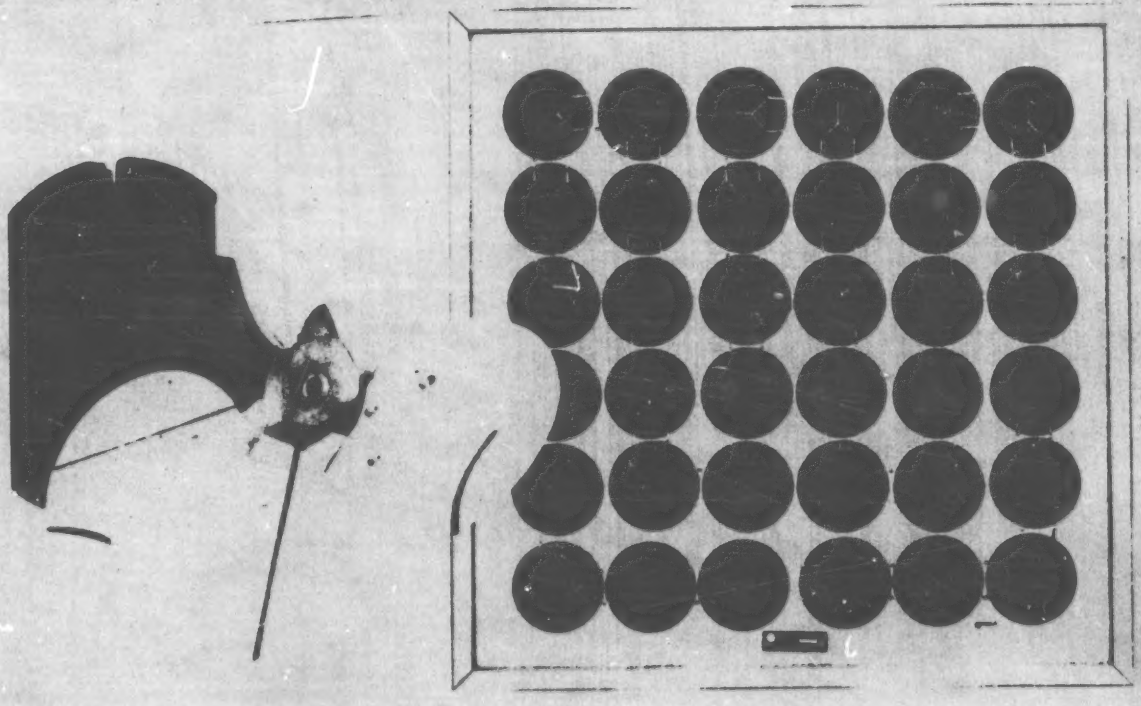
ELECTRICITY FROM THE SUN WHERE AND WHEN YOU NEED IT.

Courtesy of
MONEGON, LTD.

SOLAR ELECTRIC FANS



It's a breeze with a solar powered celing fan



Exhaust fans

Courtesy of
MONEGON, LTD.

ADVANCED SOLAR SYSTEMS
UNIT I

NAME_____

TEST

1. Match the terms on the right to their correct definitions or descriptions.

_____a. A measure of the tendency of a surface to emit radiation

_____b. The process during which a sealant becomes a flexible solid with elastic properties

_____c. The ratio of energy reflected by a surface to the energy incident on the surface

_____d. A material that retards the flow of heat

_____e. The emission of volatile additives, contaminants, or breakdown products

_____f. The hydrogen ion concentration in a liquid

_____g. The degradation of a material when exposed to the elements of outdoor atmosphere

_____h. A solar heating system that does not require an input of non-solar energy to function

_____i. A high energy radiation that makes up a portion of solar radiation

_____j. The capability of a material to cause illness, death, or damage to living tissue

_____k. Decomposition of material at high temperatures

1. Corrosion
2. Elastomer
3. Inhibitor
4. Insulation
5. Outgassing
6. Emittance
7. Curing
8. Passive system
9. Reflectance
10. Selective coating
11. pH
12. Weathering
13. Thermal degradation
14. Viscosity
15. Thermal storage medium
16. Thermal expansion
17. Thermal shock

_____l. An absorber coating that has low longwave emittance and high solar absorptance

_____m. Resistance of a fluid to flow

_____n. Increase in length or volume when the temperature is increased

_____o. The wearing away of a material by physical and/or chemical processes

_____p. A rubber-like, often synthetic, polymer that has elastic properties

_____q. A material used to retain heat in storage until it is needed

_____r. An additive to fluids which slows the rate of chemical breakdown of fluids

_____s. Response of a material when it comes in contact with another material that has a much higher or lower temperature

18. UV (ultraviolet)

19. Toxicity

2. List six possible applications of solar process heat for commercial use.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

3. Select characteristics of flat plate collectors in commercial and industrial applications by placing an x in the appropriate blanks.

___a. Are easy to install and maintain

___b. Are difficult to install

___c. Are seldom for commercial jobs

___d. Are the least expensive

___e. Are the most widely used

___f. Produce hot water to about 214°F

___g. Produce hot water to about 205°F

___h. Are modular in design

___i. Will provide heat energy only on clear days

___j. Will provide heat energy on cloudy or partly cloudy days

___k. Collectors and receivers are the same

___l. Collectors and receivers are separate units

4. Select characteristics of evacuated tube collectors for commercial and industrial applications by placing an x in the appropriate blanks.

___a. Are less efficient than flat plates

___b. Are more efficient that flat plates

___c. The receiver tube is enclosed in a metal tube

___d. The receiver tube is enclosed in a glass tube

___e. Will provide heat energy in the 350°F range

___f. Are easy to install and service

5. Select characteristics of Parabolic Concentrating collectors in commercial and industrial applications by placing an x in the appropriate blanks.

___a. Are capable of producing fluids hot enough to to operate steam or Rankine cycle engine generators for power production

___b. Are line focussing collectors

___c. Will produce fluid temperatures up to 350°F

___d. Will produce fluid temperatures up to 600°F

___e. Uses polished reflector surface to direct the incident sunlight to boiler tube

___f. Polished reflector surface directs the incident sunlight to the receiver tube

___g. Are capable of producing high temperatures for operation of Rawkine cycle engine for direct drive of turbine shaft to equipment

6. Select characteristics of Parabolic dish collectors for industrial applications by placing an x in the appropriate blanks.

___a. Resemble a radar dish

___b. Are capable of producing fluid temperatures high enough for cogeneration

___c. Designed to focus sunlight along the entire length of the receiver

___d. Designed to focus sunlight at a focal point

___e. Are designed for dual axes tracking

___f. Theoretically can produce temperatures over 2000°F

7. Select characteristics of Heliostat/central receiver systems for industrial applications by placing an x in the appropriate blanks.

___a. Are designed to produce steam for power generator

___b. Are capable of producing temperatures in excess of 2000°F

___c. Are also called power towers

___d. The collectors are remote to the receiver

___e. May be adapted to industrial plant's existing boiler system for process heat

___f. Are designed for single axes tracking

___g. Are designed for dual axes tracking

8. Match the types of solar process heating systems of the past to the dates on the right.

___a.	Operation of solar irrigation pumping system with 50 HP capacity	1. 1833
___b.	Operation of process heat system with a parabolic dish collector	2. 1890's
___c.	Operation of plant machinery with concentrator collector system	3. 1882
___d.	Operation of printing press with dish type collector	4. 1912

9. List four values of solar industrial process heat systems

a._____

_____

b._____

_____

c._____

_____

d._____

_____

10. List the approximate number of solar thermal manufactures in 1980 and give annual sales value

a. Number of manufactures_____

b. Annual sales value_____

11. Select companies that are using solar process heat by placing an x in the appropriate blanks.

___a. Disney World

___b. Pepsi Cola

___c. 7 Up Bottling Company

___d. Campbell's Soup

___e. Lone Star Brewery

___f. Johnson and Johnson

___g. Pabst Blue Lable

___h. Anheuser-Busch Brewer

___i. Sea World

___j. Manufacturing Plants

12. List four industrial applications of solar process heat in the 1980's

a._____

b._____

c._____

d._____

13. Select specific areas of concern for optimum design of solar process heat system applications by placing an x in the appropriate blanks.

___a. Return on investment

___b. Cost of system installed

___c. Cost of replacement components

___d. Heat transfer medium to be used in the process

___e. Type of heat exchange in place

___f. Skilled maintenance personnel

___g. The availability of land or roof area

___h. Flow rate of delivery system

___i. Temperature of transfer fluid

___j. Temperature required

14. List seven components of a solar powered irrigation system

1._____

2._____

3._____

4._____

5. _____

6. _____

7. _____

15. Select two types of solar grain drying systems by placing an x in the appropriate blanks.

___a. Combination high heat, low speed, pre-dry system

___b. Combination high speed, high temperature, pre-drying

___c. Low temperature, high speed, final drying

___d. Slow speed, low temperature, final drying

16. List four types of solar collectors used with grain drying systems

a. _____

b. _____

c. _____

d. _____

17. Select three methods for transporting collected heat to the grain storage area by placing an x in the appropriate blanks.

___a. Use of air duct connected to the collector system and fresh air damper

___b. Use of air duct connected to the collector system and dryer fan

___c. Use of outside air to control heat flow from collectors to storage fan

___d. Use of outside air to control heat flow from collectors to dryer fan

___e. Use of separate collector fan to deliver the recommended amount of solar heated air to the dryer fan intake

18. List two concerns in sizing solar collectors for grain drying

a. _____

_____

b._____

_____

19. List two types of solar heating systems used in livestock building and give two common characteristics of active solar systems

Type a._____

Type b._____

Characteristic a._____

_____

Characteristic b._____

_____

20. Match the types of active air collectors for livestock buildings on the left to their correct description.

___a.	Covered-plate collector	1.	Well insulated with double glazing
___b.	Suspended-plate collector	2.	Air passes over both sides of the absorber
___c.	High-efficiency, suspended-plate collector	3.	Air passes over one side only

21. Discuss three types of active-system, liquid-type solar collectors for livestock buildings.

Type a._____

Type b._____

Type c._____

_____

22. Select three common materials used as heat storage for livestock buildings and two rule-of-thumb methods of sizing heat storage by placing an x in the appropriate blanks.

a. Materials

___1. Rock salt

___2. Rock

___3. Concrete

___4. Heavy clay

___5. Water

___6. Wood chips

b. Methods

___1. 1 1/2 cubic feet of solid concrete or rock for each square foot of collector surface

___2. 1 1/2 square feet of solid concrete or rock for each square foot of collector surface

___3. 4 gallons of water for each cubic foot of collector surface

___4. 4 gallons of water for each square foot of collector surface

23. Select three statements on an in-building, vertical wall collector and storage system by placing an x in the appropriate blanks.

___a. Double glazing over absorber blocks

___b. Reflective cover for winter use

___c. Collects, delivers, and stores solar heat

___d. Single glazing over absorber blocks

___e. Reflective cover is removed for winter use

24. Discuss the function of combination collector/rock storage and water type solar system with auxiliary boiler and water storage.

a. Combination collector/rock storage

1. _____

_____

2. _____

_____

B. Water type solar system with water storage

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

_____

25. List nine applications of photovotaic power system

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

ADVANCED SOLAR SYSTEMS

UNIT I

ANSWERS TO TEST

1.

a.	6	f.	11	k.	13	p.	2
b.	7	g.	12	l.	10	q.	15
c.	9	h.	8	m.	14	r.	3
d.	4	i.	18	n.	16	s.	17
e.	5	j.	19	o.	1		

2. Any order of the following six:
   a. Space heating
   b. Absorption-air conditioning
   c. Solar process heat for manufacturing processes
   d. Steam generation
   e. Power production
   f. Hot water
3. a,d,e,g,h,j,k
4. b,d,e,f
5. a,b,d,f,g
6. a,b,d,e,f
7. a,b,c,d,e,g
8. a. 4 c. 1
   b. 2 d. 3
9. Any arrangement of the following five:
   a. Augment and integrate with convential heat plants
   b. Displace the consumption of fossil fuels when the sun shines
   c. Saves fuel and fuel cost

d. Operation and maintenance of the solar energy plant requires similiar basic skills as current fossil fuel plants

e. May be disigned for preheat applications using flat plate collector as well as concentrator

10. a. 350

b. over 175 million

11. a,d,e,f,i

12. Any order of the following:

a. Heating and cooling

b. Power production

c. Process heat applications

d. Steam applications

13. a,b,d,e,g,h,i

14. Any order of the following:

a. Trough type concentrator collector

b. Rankine freon drive engine

c. Heat transfer fluid pumps

d. Storage Tank

e. Tracking system

f. Auxiliary power supply

g. Irrigation pump motor

15. b,d,

16. Any order of the following:

a. Plastic collectors

b. Bare-plate collectors

c. Covered-plate collectors

d. Suspended-plate collectors

17. b,d,e

18. Any order of the following:

a. Sized mainly as a source of supplement heat to surrounding air

b. Solar system should add approximately 20-40% of total heat required

19. Any order of the following:

Type a. Passive system

Type b. Active system

Characteristic a. A black painted surface to absorb the suns ray's causing an increase in the temperature of the surface

Characteristic b. A transfer medium, usually air or water

20. a. 3 c. 1

b. 2

21. Discussion should include:

a. Black tubes laid on the absorber surface

b. Tubes bounded to the absorber surface

c. Formed tube-in-sheet design with 360 degree contact between absorber surface and tube surface

22. a.Materials 2,5

b.Methods 1,4

23. a,b,c

24. Discussion should include any order of the following:

a. Combination-collector/rock storage

1. Air is circulated from collector through storage and back to collector

2. Air is circulated through air ducts buried in the rock storage to the livestock building and back

b. Water type solar system with water storage

1. Solar heated water is circulated between the collectors and storage tank

2. Solar heated water is circulated through a liquid to air hydronic for coil unit

3. Solar heated air is delivered to the livestock building space

4. The auxiliary boiler provides back up heat when storage water temperature is below the design temperature

25. Any nine of the following:

1. Residential electricity needs
2. Vacation cabins
3. Recreational vehicles
4. Remote power requirements
5. Battery charging
6. Evaporative coolers
7. Refrigerators
8. Solar electric pumping systems
9. AC and DC photovoltaic power systems
10. Solar electric fans